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# HOW TO MAKE A SEWING MACHINE MOTOR WITHOUT CASTINGS.

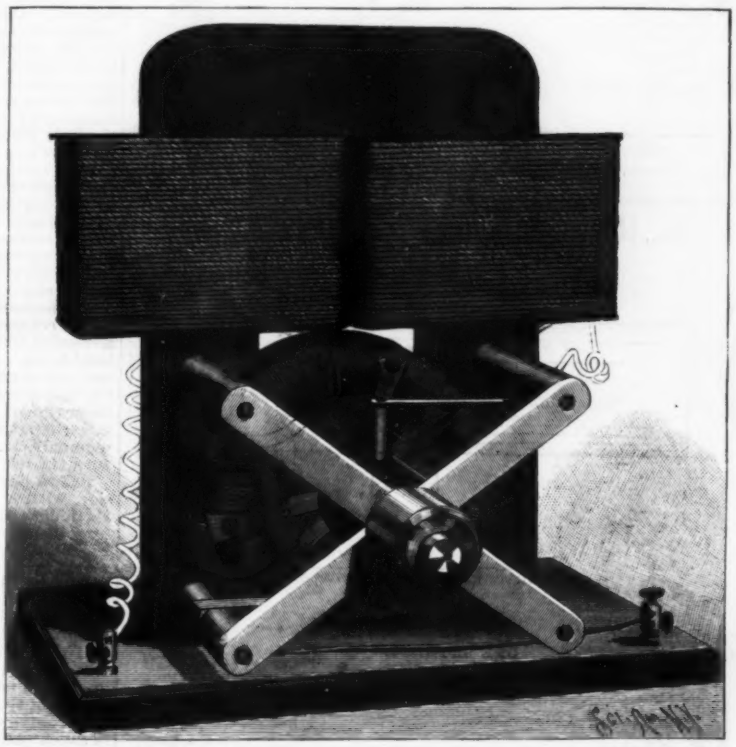
By CECIL P. POOLE.

THE accompanying drawings, together with the following instructions, will enable any mechanic of average ability to build a highly efficient motor that will operate the heaviest of family sewing machines with a consumption of electrical energy only a trifle greater than that required to maintain an incandescent lamp. All the materials entering into the construction of the motor may be procured in almost any town or small city, and the total cost of the machine, excepting, of course, the labor, should not exceed five dollars.

The first operation is that of making the magnet, which consists of a bar of ordinary wrought iron, 1⅛ inches square and 19 inches long, bent (while red hot) into a U, as shown by Fig. 1. After bending the iron into shape, cut out two concavities in the limbs, as indicated by the dotted lines, to a circle of 4¼ inches diameter. The center of the circle of which the concave surfaces form arcs must be 5⅛ inches from the short part of the U, known as the magnet yoke, and exactly midway between the magnet limbs, so that an equal amount will be cut out of each limb. This cutting can be done by any blacksmith, as it does not need to be precise in the matter of the surfaces of the concavities, the only object being to remove the bulk of metal that is to be cut away in order to form the armature chamber.

Next smooth up the sides of the magnet on the flat of an emery wheel, rounding off the corners so that a face view of the ends of the limbs will be as shown by Fig. 2; the faces, *f*, *f*, should also be smoothed off with the emery wheel, as these form the base of the machine. Then bolt the magnet to the face-plate of the lathe so that the center of the circle, *a*, to which the magnet limbs were cut away coincides with the lathe centers, and bore out the armature chamber to 4½ inches in diameter, leaving the magnet as shown by Fig. 3; the curved surfaces forming the armature chamber are known as pole-faces. If the sides of the magnet (by "sides" are meant the part facing the reader in Figs. 1, 3, and 5 and the corresponding part on the other side of the magnet) were not ground to a true parallel on the emery wheel, and it is highly probable that they were not, it is advisable to take a slight cut over the whole side exposed while the magnet is on the face-plate so as to have it perfectly plane, and also take a cut over the opposite side to insure parallelism.

The journal yokes and boxes come next. There will be two bearings and yokes, one for each side of the machine. Fig. 4 shows the parts necessary for one yoke and bearing; *y*, *y* are brass strips 6⅝ inches long, 1 inch wide, and 3/16 inch thick, with rounded ends; *b* is the box, made of a piece of round brass rod 1 inch in diameter and 2 inches long over all, one end being turned down to ¾ inch diameter for a distance of ⅜ inch, a ⅜-inch hole being drilled through the center and a ½-inch hole being drilled in one side far enough to let the point of the drill through into the bore of the box; *c* is the oil reservoir, consisting of a piece of brass tubing 1 inch long, ⅝ inch in diameter outside and ⅜ inch diameter inside, with one end permanently stopped by a plug soldered in and the other end threaded for a distance of 5/16 inch. The hole in the side of the box, *b*, is threaded to match the thread on the end of the tube, *c*, which is packed with lamp wick, filled with oil, and screwed in the box when the machine is completed and ready to run. The yoke strips, *y*, *y*, have each a ¾-inch hole drilled exactly in the center, several nicks being filed in the edges of these holes. Before putting the yoke together, tin the edges of these central holes and tin the small end of the box, *b*; then mount the strips on the end of the box so they will be at right angles with each other and so that the hole in the side of the box comes between two of the legs formed by the strips, and solder the whole at the center. Be sure to fill the nicks in the edges of the holes with solder.

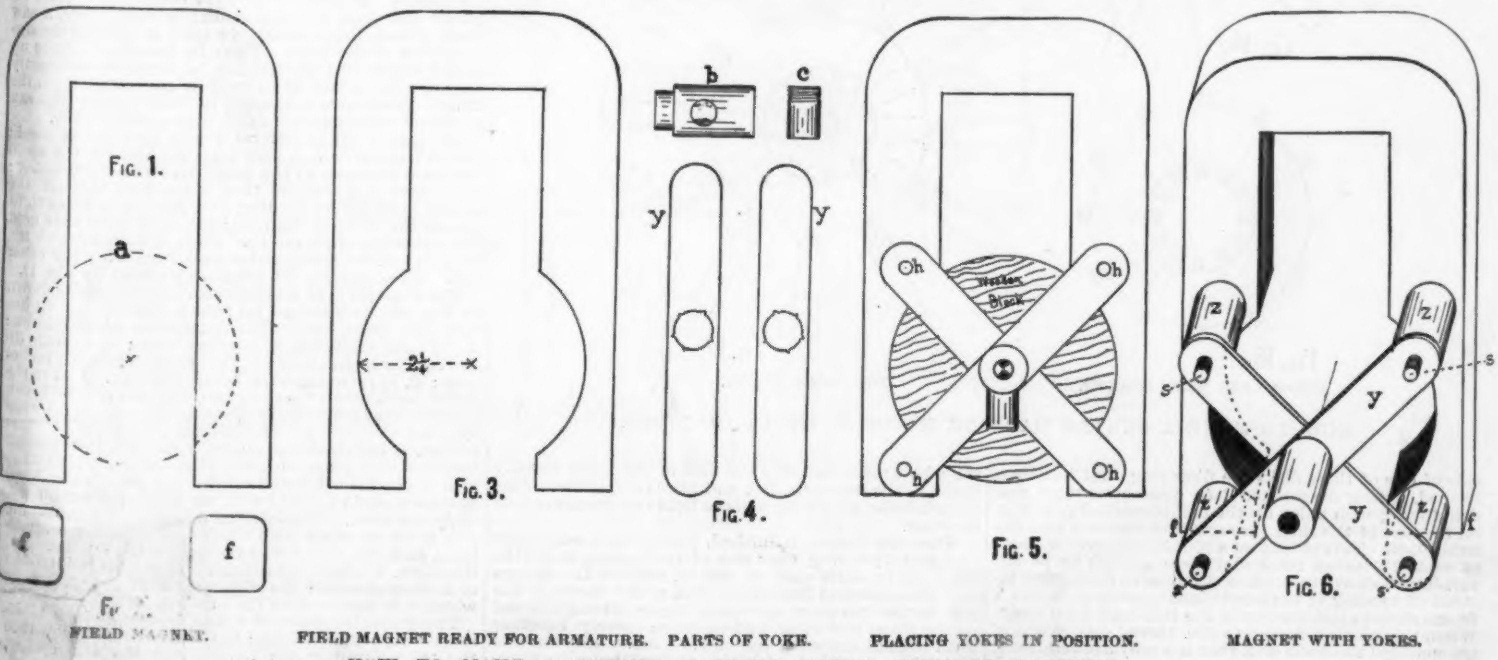


SEWING MACHINE MOTOR MADE BY AN AMATEUR.

When both yokes have been assembled, turn up a block of wood 1⅛ inches thick to fit closely the armature chamber in the magnet limbs without spreading the latter. This block should have a ⅜-inch hole in the center, and it will be better to drill the hole first, mount the block on a ⅜-inch mandrel and turn it up true with the central hole. Put this block in the armature chamber with its ⅜-inch mandrel in the central hole, thread one yoke on one end of the mandrel and the other on the other end, turning the legs of each yoke to the position shown by Fig. 5. Clamp the whole together securely and drill four ¼-inch holes, *h*, *h*, *h*, *h*, through the magnet limbs and both yokes; punch-mark one yoke and the face of the magnet limb on which it rests, so that in reassembling the machine the various parts will come back to the original position in which they were drilled; then take off the clamps and take off the yokes, remove the yokes and wooden block and anneal the magnet by heating it to a bright red and allowing the fire to die out with the iron covered up in the coals.

For mounting the yokes permanently on the magnet, four steel machine screws and eight distance pieces will be required. The screws are ¼ inch in diameter and 6¼ inches long under the head, and the head should be slotted. The distance pieces to hold the yokes away from the magnet are made from round brass rod 1 inch in diameter; two of them are 1 3/16 inches long, two are 1⅜ inches long, two are 2 11/16 inches long, and the remaining two are 2⅞ inches long. Fig. 6 shows one yoke mounted, with its distance pieces, *z*, *z*, *z*, *z*, and *s*, *s*, *s*, *s*, represent the thread ends of the screws. The yokes should be carefully fitted or trouble may result from non-alignment of the bearings.

The armature structure comes next. From some dealer in armature stampings procure one hundred rings of charcoal iron 4 inches in diameter outside and 3 inches in diameter inside. These rings must not be over 1/16 inch thick and preferably about 1/64 inch thick. Not all of the one hundred will be needed, but many will be spoiled in drilling. From a dealer in electrical supplies procure two rings of vulcanized fiber the




FIELD MAGNET. FIELD MAGNET READY FOR ARMATURE. PARTS OF YOKE. PLACING YOKES IN POSITION. MAGNET WITH YOKES.

HOW TO MAKE A SEWING MACHINE MOTOR WITHOUT CASTINGS.

same diameter outside and inside as the iron rings, and $\frac{1}{4}$ inch thick. On the face of one ring space off twelve equidistant points on a circle scribed around the center of the ring's face midway between edges, as shown by Fig. 7, in which the points are indicated by *e, e, g, e, e, g, e, e, g, e, e, g,* those marked *g* being 90 degrees apart. Take two brass disks 4 inches in diameter, $\frac{1}{4}$ inch thick, with a $\frac{1}{4}$-inch boss $1\frac{3}{8}$ inches in diameter on one side, as shown by Fig. 8, which may be obtained from any model-making establishment, and drill through the center a $\frac{3}{4}$-inch hole, indicated by dotted line in the sketch. Clamp on the smooth side of one of these disks the fiber ring that has been scribed, letting the marked face come uppermost, and drill four $\frac{1}{4}$-inch holes at the points marked *g, g, g, g,* on the face of the ring, through both the ring and the brass disk. Next mount on a $\frac{3}{4}$-inch mandrel a block of wood $2\frac{1}{4}$ inches thick and large enough to permit turning it down to a roller 3 inches in diameter; instead of turning it to measurement, however, make it fit snugly into the interior of the iron and fiber rings. When this block is turned to size, thread on one end of the mandrel the brass disk that has only a central hole, next put the unmarked fiber disk on the wooden block, down to the brass disk, and follow with the iron rings, putting on last the fiber ring that has been drilled and then threading on the mandrel the brass disk that was also drilled with the fiber disk. Turn the disk so that the holes near its edge agree with those in the fiber ring under it and compress the whole arrangement with clamps. If there are so many iron disks that the fiber ring cannot be drawn down over the end of the wooden centering block, take off enough to let this be done, as it is imperative that all the rings and disks should be accurately centered with each other. Then drill $\frac{1}{4}$-inch holes through the whole mass, entering the drill in the holes already bored in the top brass disk and fiber ring. These four $\frac{1}{4}$-inch holes are for tie-bolts to hold the armature core together.

When the drilling is finished, punch-mark each brass disk and fiber ring near one of the $\frac{1}{4}$-inch holes (the same one in each case, of course), remove the clamps and the brass and fiber pieces, run a wire through the hole in the iron rings corresponding to the one marked on the fibers and disks and tie them loosely together until time to assemble the core. Then clamp the two fiber rings together, with the marked holes in alignment, and drill through both rings a $\frac{1}{16}$-inch hole at each point marked *e*, leaving each ring as shown by Fig. 9.

Next cut out of hard wood twenty-four trapezoidal blocks (Fig. 10) $\frac{3}{8}$ inch thick, $\frac{3}{8}$ inch wide at one end, $\frac{1}{8}$ inch wide at the other, and $\frac{1}{2}$ inch long. In the center of sixteen of these drill a $\frac{1}{16}$-inch hole; in the center of the other eight drill a $\frac{1}{4}$-inch hole. Pin the sixteen trapezoids having small holes to the faces of the two fiber rings, putting the pins through from the back through the $\frac{1}{16}$-inch holes in the rings; the pins, which must be of brass, should be a tight driving fit so that the trapezoids will not tend to slip off, and the faces of the latter should be coated with shellac varnish to prevent their turning on the pins.

The tie-bolts, mentioned above, are of brass, $\frac{3}{16}$ inch in diameter and $3\frac{5}{8}$ inches long, threaded at each end for a distance of $\frac{3}{8}$ inch. They must be insulated where they pass through the core by wrapping paper on them, gluing each layer and putting on enough to make the insulated portion fit snugly in the $\frac{1}{4}$-inch holes drilled through the rings. Cut a strip of manila paper $2\frac{1}{4}$ inches wide, and wrap it tightly on the bolt, leaving an equal length of uncovered metal at each end. When the right thickness of insulation is obtained, drill two $\frac{1}{16}$-inch holes in the bolt, exactly $2\frac{1}{16}$ inches from center to center, and equal distances from each end (this distance, if the bolt has been accurately cut to the length specified, will, of course, be $\frac{25}{32}$ inch). Two nuts must be also provided for each bolt, and two steel pins which are driving fits in the $\frac{1}{16}$-inch holes, and slightly tapered. One of these tie-rods, without its nuts and pins, is shown by Fig. 11.

Then assemble the armature core on its wooden centering block, using enough iron disks to make the iron part measure $1\frac{1}{4}$ inches in thickness when compressed and being careful to have those of the $\frac{1}{4}$-inch holes that were marked on the fiber pieces come in line with the hole through which the wire holding the iron disks together was run. Leave off the brass disks for the present. Through each $\frac{1}{4}$-inch hole put a tie-rod, clamping the structure until the steel pins can be put in the holes in the tie-rods; enough iron disks should be put in to prevent any looseness when the clamps are removed. Fig. 12 shows the complete structure. After the tie-rods are pinned in place the remaining trapezoids are put on over the ends of the rods; a little groove will have to be cut in the back of the trapezoid to accommodate the steel pin in the end of the tie-rod.

The commutator comes next, and while it would be advisable to buy a complete commutator, a very serviceable one can be made with proper care in following out the instructions given. If the builder prefers to buy the commutator, the dimensions accompanying the order must be these: Diameter of brush surface, 1 inch; length along the shaft, $1\frac{1}{4}$ inches; number of segments, 12. If the commutator is to be built along with the rest of the machine, proceed as follows:

Take a piece of brass tubing 1 inch in diameter outside, with a wall about $\frac{1}{8}$ inch thick, and measuring $2\frac{1}{2}$ inches long. Slit it at twelve equidistant points for a distance of $1\frac{1}{4}$ inches from one end, as shown by Fig. 13, and insert the unslitted portion in a hole in a block of wood that just fits the tubing; the block should be 1 inch thick and nailed to a bench or other support. Then bend outwardly the narrow strips made by slitting the tubing until it looks like Fig. 14; the wings should be brought to a right angle with the body of the tubing not slitted, and hammered out flat. Number the "wings" by means of punch marks, from one up to twelve, and then carry the slits along the length of the uncut portion of the tube, cutting it up into twelve pieces like Fig. 15. Next turn up two rings of vulcanized fiber 2 inches in diameter outside, 1 inch in diameter inside and $\frac{1}{4}$ inch thick, and fit around the circumference of each twelve steel screws, $\frac{1}{8}$ inch in diameter and $\frac{3}{4}$ inch long over all, without heads, as shown by Fig. 16, the screw-holes being carried clear through so that the point of the screw may emerge on the inside of the ring. Cut thirty-six strips of oil paper (the kind used with copying books to protect the leaves from moisture) $\frac{1}{64}$ inch thick, $\frac{1}{4}$ inch wide, and $1\frac{1}{2}$ inches long. Assemble the pieces of the commutator in numerical order within the two fiber rings, one ring at the wing end and one at the other end of the tubular part, put three slips of oil paper between each pair of neighboring pieces of tube, and draw the segments toward the center by means of the little screws until the oil paper slips are clamped so tightly between the brass segments that they cannot be pulled out with the fingers. In order to have the commutator come together and form an approximately true circle, a saw blade $\frac{1}{32}$ inch thick should be used in cutting the segments out of the tube. Then by judicious setting up on the screws the surface can be brought sufficiently near to a true circle as to require no truing up in the lathe. The protruding edges of the oil-paper slips can be cut off even with the brass with a sharp knife.

The core of the commutator may be made of wood; mount a block on a $\frac{5}{8}$-inch mandrel and turn it up to the exact diameter of the interior of the commutator; then taper it slightly so that it will pass through the commutator before binding, and drive it home as tight as possible without straining the fiber rings that hold the segments. Cut off the block $\frac{1}{8}$ inch beyond the wing end of the commutator and flush with the other end. The complete commutator is shown by Fig. 17.

The next piece of machine work is the shaft, shown by Fig. 18. It is turned up from a piece of $\frac{7}{8}$-inch bar steel $10\frac{1}{8}$ inches long. The dimensions are as follows: *A*, $\frac{3}{8}$ inch diameter, $2\frac{1}{16}$ inches long; *B*, $\frac{5}{8}$ inch diameter, $1\frac{1}{8}$ inches long; *C*, $\frac{3}{4}$ inch diameter, $3\frac{3}{4}$ inches long; *D*, $\frac{3}{8}$ inch diameter, $3\frac{1}{16}$ inches long. Last in the list of machine work on the motor proper are the brush holders, one of which is shown by Fig. 19, the drawing showing two views. The holder is a piece of brass tubing, $\frac{1}{2}$ inch internal diameter and $1\frac{1}{4}$ inches long, mounted on a piece of strip brass $\frac{5}{8}$ inch wide and $\frac{1}{16}$ inch thick, the other end of which is bent into a loop, as shown, and provided with an insulating bushing, *t*, of $\frac{1}{16}$-inch fiber. The internal diameter of the bushing is a trifle over an inch when the clamping screw is loose, and the diameter of the loop in the brass strip is, therefore, $1\frac{1}{8}$ inch maximum. This loop is intended to fit around one of the distance pieces, *z*, Fig. 6, from which it is insulated by the bushing, *t*.

The brush is a piece of round carbon, $\frac{1}{2}$ inch in diameter and 1 inch long; it should fit snugly within the tube forming the holder, and a spir. l spring,

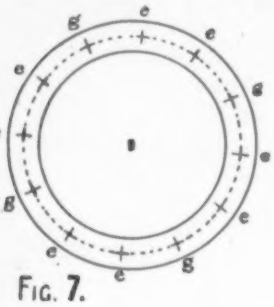


FIG. 7.

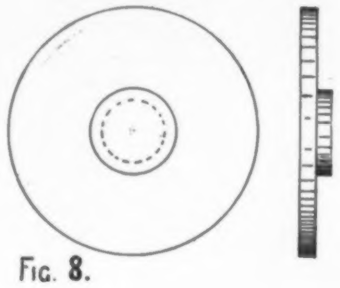


FIG. 8.

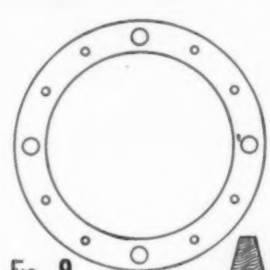


FIG. 9

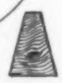


FIG. 10.

LAYING OUT THE ARMATURE. BRASS DISKS. POSITION OF HOLES FOR BOLTS. A TRAPEZOID.

TIE ROD.

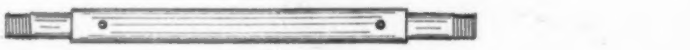


FIG. 11.

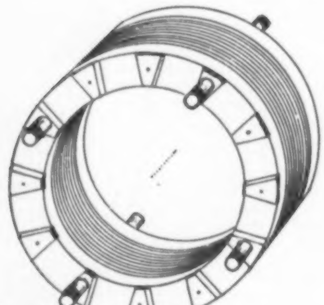


FIG. 12.

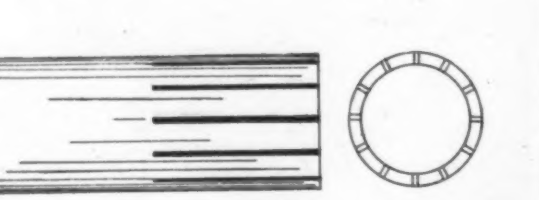


FIG. 13.

ARMATURE READY FOR WINDING. THE SLITTED TUBE FOR COMMUTATOR.

COMMUTATOR TUBE BEFORE IT IS CUT INTO SEGMENTS. ONE SEGMENT.

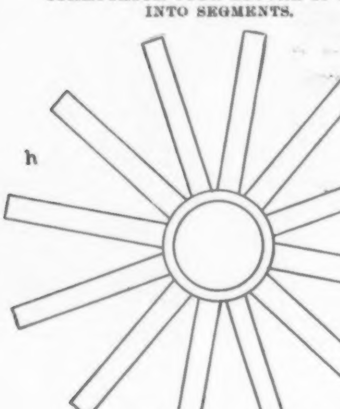


FIG. 14.

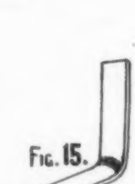


FIG. 15.

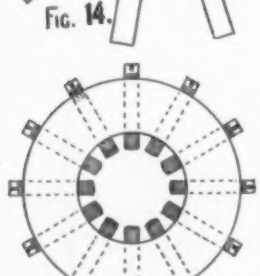


FIG. 16.

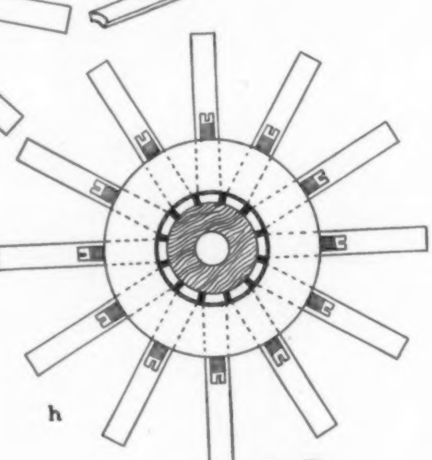


FIG. 17.

FIBER RING WITH SCREWS. THE COMMUTATOR.

HOW TO MAKE A SEWING MACHINE MOTOR WITHOUT CASTINGS.

$\frac{3}{8}$ inch in diameter, made of No. 16 brass wire, must be provided to force the brush outwardly on to the commutator. One brush holder is attached to the lower left-hand distance-piece, *z*, and the other to the upper right-hand piece, the tubular part of the holder setting vertically, between the magnet poles, with its inner end not more than $\frac{1}{8}$ inch from the surface of the commutator. Electrical connection is made with the brush arm by means of a piece of flexible cord, such as is used in hanging incandescent lamps, one end of the cord being soldered to a copper washer, which is clamped under the head of the screw on the brush arm.

THE SHAFT.

FIG. 18.

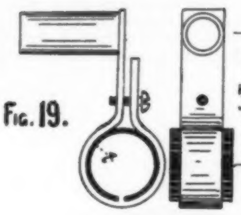




FIG. 19.

BRUSH HOLDERS.

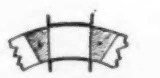


FIG. 20.

SECTION PREPARED FOR WINDING.

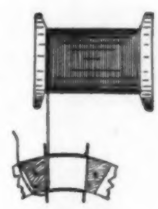


FIG. 21.

BEGINNING THE WINDING.

This cord is known as No. 18 cotton-covered lamp-cord, and may be procured from any dealer. It should be untwisted and one length used on each brush holder; the cord need not be more than 6 inches long.

We are now ready to wind the magnet and armature cores. The armature core must first be covered all around the outside surface with muslin; cut a strip 2 inches wide and 25 inches long and, after varnishing the periphery of the core with shellac, wind on this muslin strip, being sure that it is tightly wound. If it is pulled tight, it will make two layers; when the strip has been carried once around, varnish the surface of what is on the core, and then wind on the other layer of muslin. Then varnish the whole outside surface. Cut out 24 strips of oil paper, each $1\frac{3}{16}$ inches wide and 2 inches long, and bend up the edges, making the crease $\frac{1}{4}$ inch from each edge, so as to form shallow troughs the width of which will be the same as the space between the trapezoids on the ends of the core; apply two of the troughs to the inside and outside circles of the core, as shown in Fig. 20, and tie them in place with No. 40 or No. 50 sewing cotton, one strand at each side of the trough. Then wind on an old cotton-spool 68 feet of No. 20 double cotton-covered magnet wire, hook the outer end around one trapezoid, as in Fig. 21, and wind into the wiring space between this trapezoid and its right-hand neighbor a coil the full width of the space, which should take 26 turns in width, putting five layers in, or 130 turns, to each coil. When the first coil is done twist to the final end the beginning end of the wire which is to wind the next coil, and proceed with that one in the same way. Care must be observed to put exactly the same number of turns in each coil and to twist the ending of each coil to the beginning of its neighbor on the right. When the armature is wound, put on the brass disks that were left off when the core was assembled, threading the tie-rods through the holes near the edges of the disks, and putting the boss on each disk outside; clamp the disks hard against the wooden trapezoids by means of nuts on the tie-rods. The holes in the disks must be bushed with little pieces of fiber tubing and a fiber washer must go under each nut, in order to insulate the tie-rods from the disks; otherwise the armature would run destructively hot.

Insert the shaft in the center of the structure, letting that part marked *B* in Fig. 18 come on the side where the ends of the armature winding are, and pin the brass disks to the shaft through the bosses. The commutator goes on the part of the shaft just referred to, and it should be a driving fit, so as to obviate pinning or keying it to the shaft. Then connect up the ends of the armature coils to the lugs of the commutator, leading each end straight out, parallel with the shaft, to the nearest lug. If the ends were twisted together in accordance with the directions, the result will be as shown diagrammatically by Fig. 22.

Prepare for winding the magnet coils by making a winding bobbin as follows: On a piece of board an inch thick and 4 inches square lay out a square measuring $1\frac{3}{8}$ inches on a side, the scribed square being symmetrical with the edges of the board; clamp another similar piece of board to the one marked, and at the corners of the scribed square drill $\frac{1}{4}$-inch holes through both boards; in the center of the square drill a $\frac{1}{2}$-inch hole. Then make a mandrel of $\frac{1}{2}$-inch round iron, the central part being full diameter and $2\frac{1}{2}$ inches long, and the ends being turned down to pass through the central hole in the board. Mount the boards on the ends of the mandrel and run $\frac{1}{4}$-inch iron rods through the corner holes, forming a sort of reel, as shown by Fig. 23. Jam the boards against the shoulders of the mandrel by means of lathe dogs on the outer ends of the latter, and drive a nail in the face of each board so that the dog will drive the board without slip. The dogs must be so adjusted, of course, as to drive both boards in their proper angular positions, maintaining the parallelism between the $\frac{1}{4}$-inch rods and the mandrel that is necessary to form a perfect coil.

Mount this winding frame in the lathe and wind a coil on it of No. 21 double cotton-covered magnet wire, putting as many turns as possible (it should take sixty-six) between the faces of the wooden blocks and making the coil twenty-seven layers deep. The starting end may be secured to the projecting end of one of the $\frac{1}{4}$-inch rods to give the necessary tension to the first layer of wire, and at least a foot of the starting end should be left free. When the coil is finished, tie it at each of the four corners with strong linen thread, bending the final end sharply backward over one of these corner threads to keep the top layer snug; take the winding frame apart and varnish the coil all over with shellac, setting it aside to dry while the second coil is wound. This is exactly like the one already wound.

Then take the journal yokes and their bolts and distance pieces off the magnet and wrap the magnet limbs with muslin from $\frac{1}{2}$ inch above the bolt holes up to the bend, putting two layers on each limb and varnishing it on the outside of each layer. When this is dry, turn the magnet upside down, thread on each limb a fiber washer $3\frac{3}{4}$ inches square and $\frac{1}{8}$ inch thick, the hole in the washer fitting the magnet limb snugly; varnish the faces of the washers now uppermost and slip the coils on the limbs down on the washers while the varnish is wet, so that the latter will stick to the coils. In putting on the coils, see that the beginning end of each coil goes on first, so that when the machine is set right side up the final end of each coil will be nearest the armature. Follow each coil with another fiber washer like those first put on the magnet, and then reassemble the journal yokes and distance pieces on the magnet, this time putting in the armature as you go along and also putting on the brushholders and brushes. The holders should be so adjusted that the ends of the brush tubes are $\frac{1}{16}$ to $\frac{1}{8}$ inch away from the surface of the commutator.

The free ends of the magnet coils nearest the armature are connected to the brushes by means of flexible lamp cord, as described in the instructions for making the brush holders, the end of the flexible cord being soldered to the end of the magnet wire close up to the coil. The upper ends of the magnet coils go to the terminal block, which is a block of wood, $1\frac{3}{4}$ inches square and 4 inches long, bolted on the top of the magnet yoke, and carrying two binding posts, which form the terminals of the machine. The motor is bolted to the

THE WINDING.

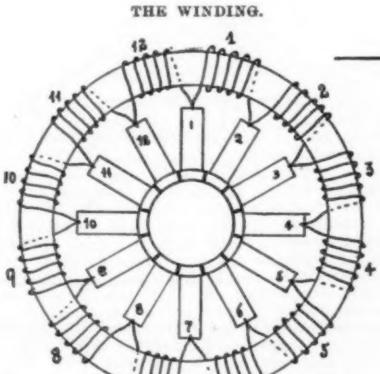



FIG. 22.

REGULATOR—FRONT VIEW.

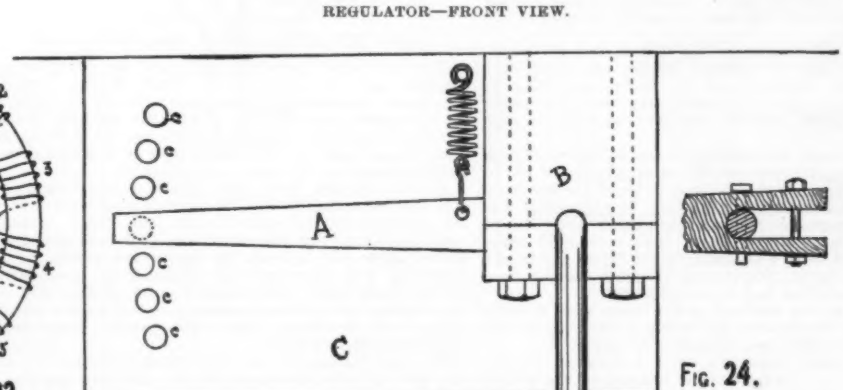



FIG. 24.

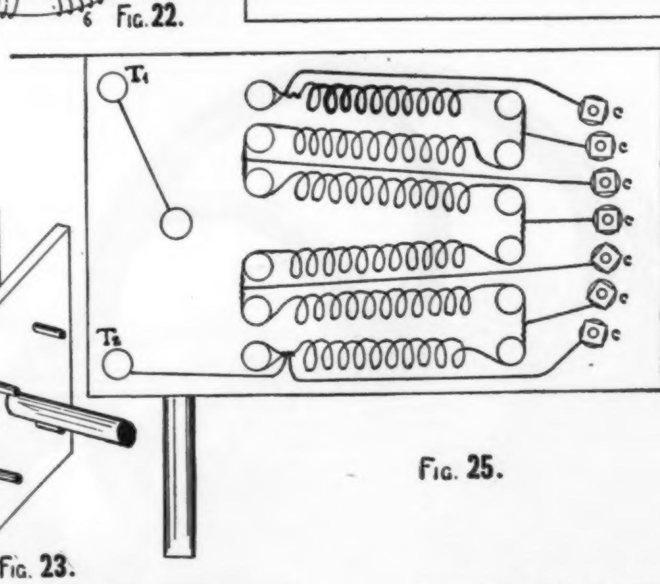



FIG. 25.

REGULATOR—BACK VIEW.

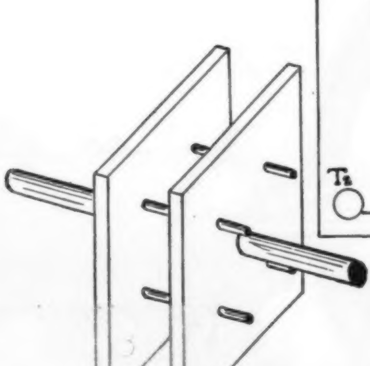


FIG. 23.

REEL FOR WINDING FIELD MAGNET COILS.

HOW TO MAKE A SEWING MACHINE MOTOR WITHOUT CASTINGS.

table of the sewing machine, with one leg right on the edge of the table and in such position that the pulley of the motor, which must go on the end of the shaft away from the commutator, is in line with the belt pulley of the machine. The motor pulley should be one-half the diameter of the pulley on the sewing machine, and be of the same width and depth of groove.

The regulator is shown by Figs. 24 and 25, the former being the front view and the latter the back. Referring to Fig. 24, *A* is a wooden arm, $9\frac{1}{8}$ inches long, $\frac{1}{8}$ inch thick, and tapering from $\frac{1}{8}$ inch to $1\frac{1}{4}$ inches in width. The narrow end is faced with a thin strip of copper to make contact with the buttons, *c*, which are simple brass bolts with flat heads; the wide end of the wooden arm is split to straddle the shaft, to which it is pinned as well as clamped. *L* is the lever controlling the arm, *A*; it is made of $\frac{1}{8}$-inch round iron rod, bent to form a right angle; the lever portion is 6 inches long; the length of the horizontal portion on which the lever, *A*, is mounted is the same as the width of the sewing machine table on which the motor is to be used. The back end of the shaft is journaled in the base board, *C*, and the front part in a wooden bearing, *B*, which is bolted to the under side of the sewing machine table between the narrow drawer and the pan. The base board, *C*, is 6 inches wide (vertically) and $10\frac{1}{2}$ inches long. It is fastened to the under side of the machine table, flush with the back edge. The lever, *L*, is to be moved by the right knee of the machine operator.

The arm, *A*, is normally held in its highest position by the coil spring shown, in which position the current is cut off the motor entirely. The contact buttons, *c*, are $\frac{1}{8}$ inch in diameter; the bolts of which they are the heads are $\frac{1}{16}$ inch in diameter and long enough to protrude $\frac{1}{8}$ inch on the reverse side of the base board. This side is shown by Fig. 25. The resistance coils consist of German silver wire, No. 20 B. and S. gage, wound into coils on a $\frac{3}{8}$-inch rod (the rod being removed, of course, when the coil is formed). The piece of wire forming the upper coil should be 100 feet long; the next coils contain 90, 80, 70, 60, and 50 feet of wire, respectively, in the order named. The binding posts, $T_1$ and $T_2$, are connected as shown, the connection between $T_1$ and the iron shaft being made by means of flexible cord which will follow the movements of the shaft. On the front the shaft is connected to the copper facing at the small end of the arm, *A*, by means of No. 16 copper wire. All the connections on the back are made with No. 16 copper wire, preferably but not necessarily insulated.

The back surface of the base board must be covered with a sheet of asbestos over a thin sheet of fiber. The ends of the resistance coils are twisted together and soldered, and the connecting wires should be soldered on at the same time. The coils are held on ordinary porcelain knobs, fastened to the board by wood screws. The connecting wires should be bent into loops where they connect with the bolts, *c*, and a copper washer should go under each nut and on top of the loop of the connecting wire.

The connections between the motor and the regulator and the source of current supply are as follows: From $T_1$ to one binding post on the motor, from $T_2$ to one side of the supply circuit, and from the other binding post on the motor to the other side of the supply circuit.

The motor above described will run satisfactorily on any direct-current incandescent lamp circuit of 100 to 120 volts pressure. If it is desired to build the machine for use in connection with a battery, the windings will have to be changed as follows: Armature coils, No. 13 wire, 8 turns wide and 1 deep, each coil; field magnet coils, No. 8 wire, 5 layers deep, 18 turns per layer, each coil; regulator, No. 13 wire, the coils having one-tenth the number of feet specified above.

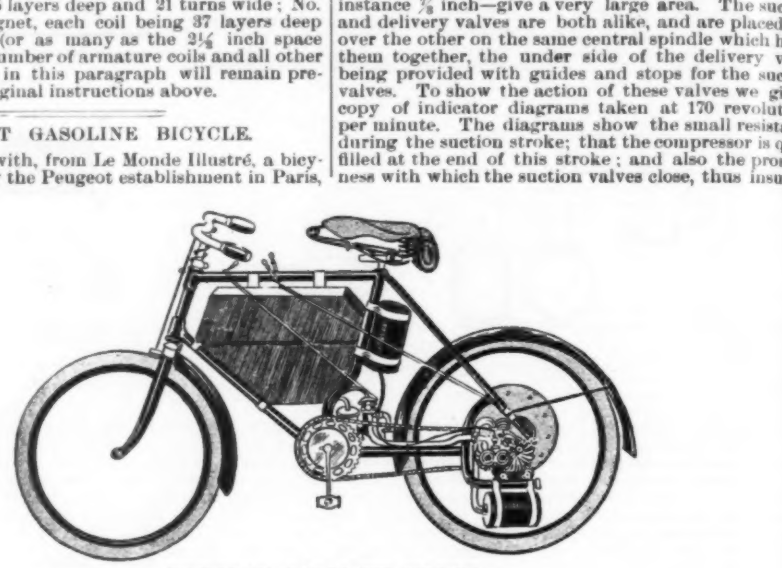
The battery to run such a motor must give 8 volts and from 10 to 20 amperes, according to the load on the motor; consequently four cells will be required.

Should the reader desire to build a standard shunt-wound motor of $\frac{1}{8}$ horse power instead of the series-wound type specified, the same frame may be used, the only variation being in the manner of winding. In order to wind the machine as a $\frac{1}{8}$ horse power motor, to work on a 110 volt circuit, the armature coils must consist of No. 27 wire, double cotton-covered, each coil being 9 layers deep and 28 turns in width—252 turns, total, per coil. The magnet coils will consist of No. 25 wire wound to a depth of 39 layers, with as many turns lengthwise as can be got in the space of $2\frac{1}{8}$ inches allotted for the coil length; with careful winding, 92 turns can be put in each layer, giving each magnet coil a total of 3,588 turns.

In order to change the design into a $\frac{1}{4}$ horse power motor, the magnet must be made of iron $2\frac{1}{8}$ inches square, instead of $1\frac{1}{8}$ inches, and the armature, shaft, journal-yoke bolts, etc., must be made exactly 1 inch longer, axially, than the above measurements specify. The windings will be No. 24 wire on the armature, each coil 5 layers deep and 21 turns wide; No. 22 wire on the magnet, each coil being 37 layers deep and 74 turns long (or as many as the $2\frac{1}{8}$ inch space will take). The number of armature coils and all other data not specified in this paragraph will remain precisely as in the original instructions above.

## PEUGEOT GASOLINE BICYCLE.

We figure herewith, from Le Monde Illustré, a bicycle constructed by the Peugeot establishment in Paris, and exhibited at the recent Salon du Cycle et de l'Automobile at the Champ-de-Mars. This machine is provided with a De Dion motor, which is placed directly in the axis of the driving wheel—an arrangement that ought to give the apparatus stability and allow of no loss of power.



PEUGEOT GASOLINE MOTOR.

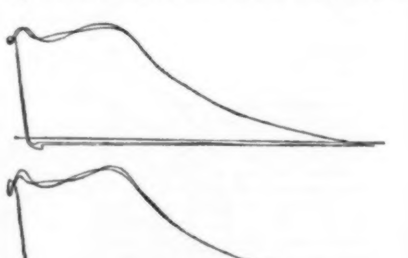
## GAS ENGINES AND LIGHTHOUSES.

We illustrate herewith one of a set of three gas engines and air compressors which Messrs. Crossley Brothers, Limited, of Manchester, have supplied to the Commissioners of Irish Lights for working the fog signaling apparatus in the lighthouse at Mew Island, near Donaghadee, at the south side of the entrance to Belfast Lough.

As will be seen from the woodcut, the compressor cylinder faces that of the gas engine, and both pistons are coupled to the same crank pin. This arrangement makes a well-balanced job, and the strains are easily taken up. In such an important matter as fog signaling it is essential that the risk of breakdowns during work shall be eliminated as far as possible. Direct driving is therefore preferable; and to suit the gas engine it is necessary that high-speeded compressors should be employed.

The gas engines are of 14 nominal horse power, and run at 170 revolutions a minute, and are capable of indicating 42 horse power as a maximum. The compressor cylinders are 14 inches diameter by 21 inches stroke, and are single acting. Each compressor is capable of delivering 280 cubic feet of free air per minute and afterward compressing it to 25 pounds per square inch. The fly wheel is 7 feet diameter by $8\frac{3}{4}$ inches wide, and an outer bearing is provided to support the overhang of the wheel. Each engine and compressor is mounted on the same cast iron foundation, and they are held together by strong wrought iron stays. The compressor cylinder is water-jacketed, and the suction and delivery valves are made under Atkinson's patent, and are particularly suited for high speed compressors.

The valves consist of a number of flat rings placed one inside the other concentrically, and seated over narrow angular passages in the valve seatings. The air passes both the inner and outer edges of the valves, which, although they have a very small lift—in this instance $\frac{7}{8}$ inch—give a very large area. The suction and delivery valves are both alike, and are placed one over the other on the same central spindle which holds them together, the under side of the delivery valve being provided with guides and stops for the suction valves. To show the action of these valves we give a copy of indicator diagrams taken at 170 revolutions per minute. The diagrams show the small resistance during the suction stroke; that the compressor is quite filled at the end of this stroke; and also the promptness with which the suction valves close, thus insuring the commencement of compression coincident with the commencement of the compression stroke. The delivery line is not flat, but this is due to wave action in the delivery main. The small loop at the end of the delivery stroke is largely due to the stretching of the



indicator string and the looseness of the indicator gear. The prompt closing of the delivery valves is also shown, together with the small clearance space and the early recommencement of the suction. The compressors are also fitted with Atkinson's patent

COMBINED GAS ENGINE AND AIR COMPRESSOR.

easing gear, which automatically stops the delivery of air when the desired pressure is attained in the receiver by holding up the suction valves.

The engines work with coal gas which is made on the island. Two engines and compressors will usually be worked, with the third as a stand-by. They will deliver air into two receivers fixed in the engine house, whence it will be taken by means of wrought iron pipes to another receiver placed in the top room of the lighthouse. The sirens will be fixed on a balcony outside this room at an elevation of 100 feet above high water mark. The air from the air receiver will be admitted to the sirens by means of valves actuated by clockwork. Two 6 inch double note automatic sirens will be employed, and will be sounded simultaneously, giving a low note of four seconds' duration, followed after an interval of twelve seconds by a blast on a higher note of four seconds' duration every two minutes. Two sirens are required, owing to the large arc over which the signal must be audible, and the two trumpets will be pointed in different directions to better distribute the sound. This installation is intended to replace an existing one, which consists of a 4 inch double note siren fixed in the engine house, and driven by two Crossley gas engines of 11 brake horse power, and which is now too small.

The work has been carried out under the superintendence of Mr. Douglas, engineer to the Commissioners. We are indebted to The Engineer for the engravings and description.

## AUTOMATIC DOUBLE CROSS-CUTTING SAW FOR HARD WOOD.

WE illustrate on this page a double cross-cut saw constructed by Messrs. A. Ransome & Company, of the Stanley Works, Chelsea, for making hard wood paving blocks. The machines are claimed to stand alone in the matter of cutting paving blocks from Australian karri and jarrah timbers in a rapid, economic, and otherwise satisfactory manner. They have been designed specially to this end and give a clean and accurate cut. All working parts are made of great strength and the saw spindles run at a speed of 1,000 revolutions per minute. The machine can be fitted with either one or two tables; that is to say, it can be used as a single or double machine, the one shown in the engraving being of the latter description. The plank, which rests on a series of turned rollers, is brought to the saw by hand, guided by an angle iron fence to insure the blocks being cut square. An adjustable stop is provided inside the framing of the machine against which the plank is brought up after each stroke of the saw, so that each block is cut to an exact length. The saw spindle rises and falls thirty-four times in one minute, cutting off two blocks at each stroke, in the case of the double machine. The rise and fall motion is imparted by means of powerful gearing working the crank disk as shown. This actuates a rocking lever by means of a strong steel connecting rod, the length of which can be adjusted by a right and left-handed screw coupling to allow for the wear of the saw. The saw blades are of very large diameter, viz., 36 in., thus insuring a clean cut, and they are supported over a great portion of their surface by cast-iron plates on either side, thus preventing any tendency the blades would otherwise have to buckle or get out of truth when working on the very hard wood for which they are designed. Two pairs of collars of smaller diameter are supplied with the machine for use when the saws have worn down, and as the saws overhang their bearings they can be exchanged when dull with the least possible delay. This effects an important saving of time, as saws cutting at such high speeds require sharpening every few hours. The saw-spindle bearings rise and fall on four turned steel columns, and the slides are made of great length, thus reducing all possibility of play to a minimum.

The saw-spindle carriages are counterbalanced by means of two weights to reduce as far as possible the vibration of the machine. The average output of this machine is 36,000 blocks a day. The weight complete is 65 cwt., and the over-all length is about 28 feet. The single machine weighs 53 cwt., and its over-all length is about 18 feet.—We are indebted to London Engineering for the engraving and article.

## PNEUMATIC GRAIN ELEVATOR.

THERE has recently been formed at Paris what is called the Société de l'Elevateur Pneumatique à Marche Continue, the object of which is to exploit a grain elevator devised by M. Emile Blanchard.

In this elevator the arrangements employed for effecting the pneumatic propulsion of the grain are set automatically in play by means of steam. They consist essentially of two tight chambers, $E$ $E'$, into which the grain is first sucked and then forced to a wharf or to storehouses. From the lower part of these chambers start the pipes, $a$ $a'$, which are connected with one suction conduit, $A$, in common, and, from the upper part, the pipes, $b$ $b'$, which are connected with one force pipe, $B$, in common.

The automatic apparatus for distributing air consists of two cylinders, $c$ and $c'$, that communicate respectively, through passages, $e$ and $e'$, with the tight chambers of the elevator, as well as with the suction and force tubes, $I$ and $I'$, connected with air pumps actuated by a steam engine. According to their positions, the slide valves or pistons of these cylinders put

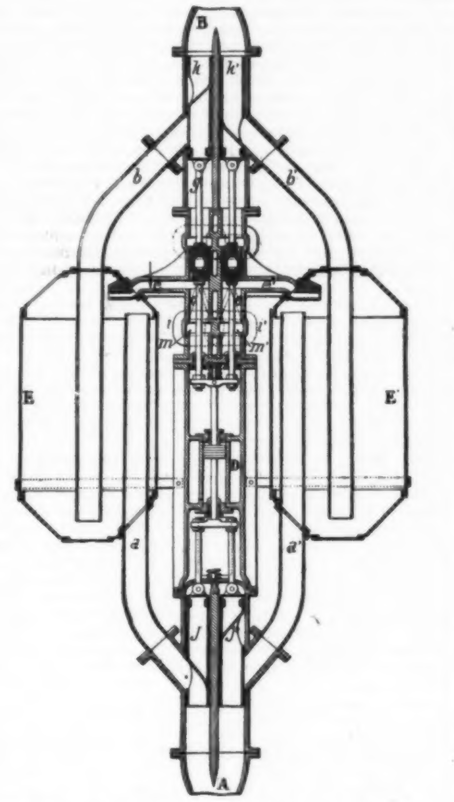


FIG. 1.—VERTICAL SECTION OF THE ELEVATOR.

in connection one of the propulsion chambers, $E$ or $E'$, with the suction pipe, $I$, of the air pumps, and the other chamber with the force pipe, $I'$, and vice versa.

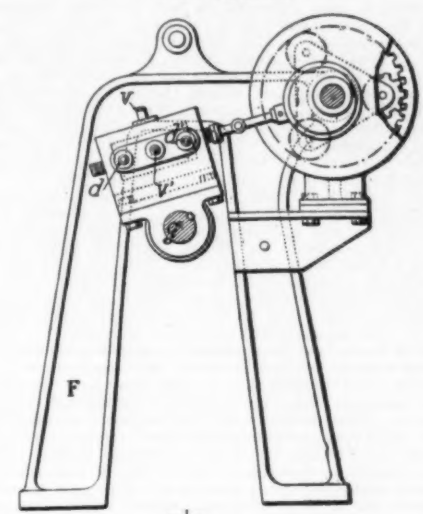
The rods of the slide valves are connected by a cross head with the steam piston rod, $D$, which moves vertically and receives the steam alternately upon each of its faces. The piston is, in addition, connected at the bottom with two cut-offs, $j$ $j'$, which it maneuvers simultaneously, and which open or close the air ways of the pipes, $a$ $a'$, into the common suction conduit, $A$. Finally, with the valve rods, $g$, are coupled analogous cut-offs, $k$ $k'$, which are movable in front of the mouths of the pipes, $b$ $b'$, that lead to the force pipe, $B$.

It results from such arrangements that the up and down motion of the steam piston, $D$, opens alternately to the suction and expulsion of the air each of the chambers, $E$ $E'$, into which the grain is consequently sucked, and from which it is afterward expelled.

In Fig. 1 all the parts of this elevator are represented in their highest position. The chamber, $E$, opened by the cut-off, $j$, and closed by $k$, communicates, through the channel, $e$, the cylinder, $c$, and the passage, $m$, with the pipe, $i$, through which the air is sucked, while the chamber, $E'$, closed at $j'$, and open at $k'$, connects, through the channel, $e'$, the cylinder, $c'$, and the passage, $m'$, with the pipe, $i'$, through which the air is forced.

If, now, steam be admitted to the upper face of the piston, $D$, and the bottom of the cylinder be open at the escapement, the descending motion that results will reverse the position of all the distributing parts,

FIG. 2.—ARRANGEMENT FOR DISTRIBUTING THE STEAM.



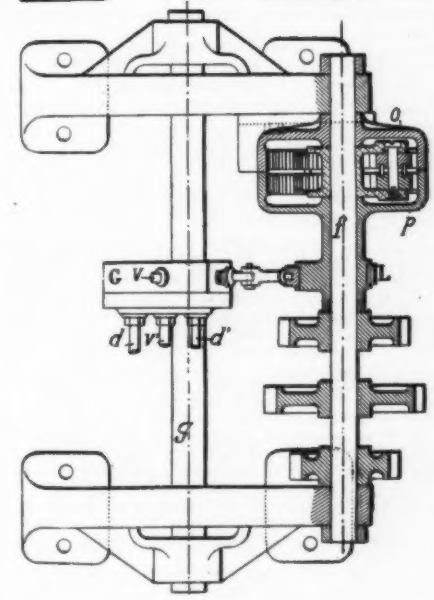
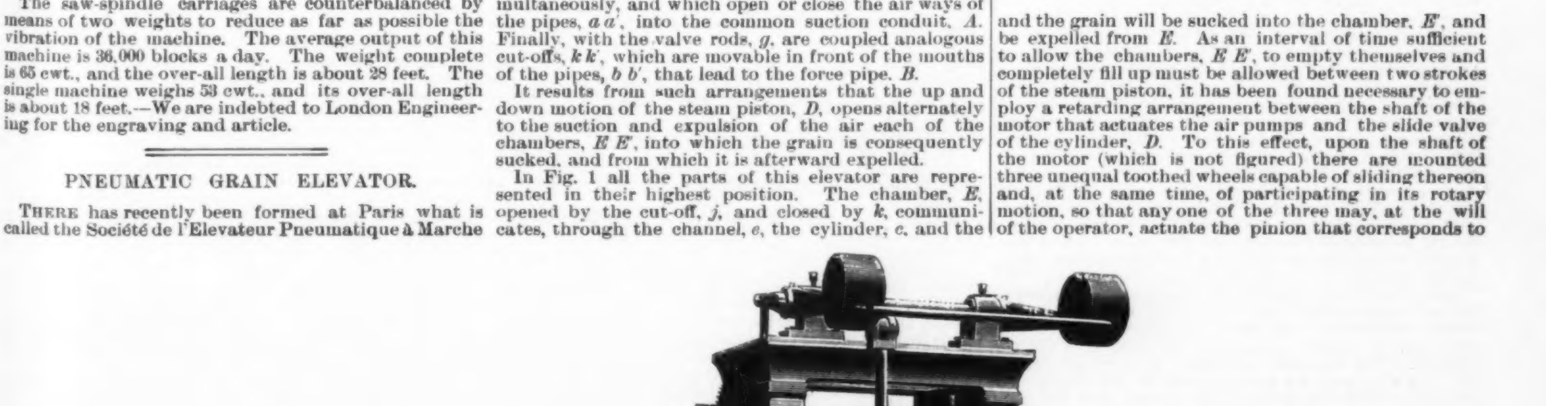


FIG. 3.—PLAN.

and the grain will be sucked into the chamber, $E'$, and be expelled from $E$. As an interval of time sufficient to allow the chambers, $E$ $E'$, to empty themselves and completely fill up must be allowed between two strokes of the steam piston, it has been found necessary to employ a retarding arrangement between the shaft of the motor that actuates the air pumps and the slide valve of the cylinder, $D$. To this effect, upon the shaft of the motor (which is not figured) there are mounted three unequal toothed wheels capable of sliding thereon and, at the same time, of participating in its rotary motion, so that any one of the three may, at the will of the operator, actuate the pinion that corresponds to



AUTOMATIC CROSS-CUT SAW FOR HARD WOOD PAVING BLOCKS.

it, and that forms part of a play of three pinions of different diameters keyed upon the intermediate shaft, *f*, of a frame, *F* (Fig. 2). This latter, through a rod, *g*, carries the distributer, *G*, of steam to the cylinder, *D*, of the pneumatic elevator.

The live steam enters this box through the pipe, *v*, and is distributed to the cylinder, *D*, by the conduits, *d* and *d'*; and its escapement at every stroke of the piston is effected through the pipe, *v'*, which debouches into the atmosphere.

The slide valve of this box is actuated with a velocity that is properly retarded by an eccentric, *L*, revolving under the action of a differential gearing mounted upon the shaft, *f*, and arranged in the following manner: Upon this shaft there are two loose wheels, *o* and *p*, toothed internally. The first of these, which has 39 teeth, is firmly fixed to the frame, *F*, while the second, which has 40 teeth, carries in the prolongation of its hub an eccentric, *L*, of which the collar actuates the distributing valve, *G*. Between these two wheels there is fixed upon the shaft, *f*, a triangular plate, each of the summits of which forms a shell containing a pair of planet wheels movable around the same axis and meshing respectively with the internal teeth of the wheels, *o* and *p*. These planet wheels naturally have a pitch appropriate to such teeth. Pins inserted half way into one and half way into the other render the two interdependent. It follows that the wheel, *p*, revolves by one tooth at every revolution of the shaft, *f*, and that it requires forty revolutions of the latter to cause this wheel to make one complete revolution, that is to say, to cause one to and fro travel of the eccentric, *L*, that actuates the distributing valve.

Since there are disposable three ratios of velocity for the control of the intermediate shaft, it will be seen that the motions of the valve may have the slowness necessary for the proper operation of the apparatus. This method of retardation is simple and sure. It is perhaps such properties that have induced the inventor to employ it in preference to the system that consists in causing the slide valve to move very rapidly, and in effecting a stoppage of proper duration between its travels.—For the above particulars and the illustrations we are indebted to the Revue Industrielle.

## NERNST'S ELECTRIC LIGHT.*

By James Swinburne.

Before describing Nernst's invention, it may be profitable to spend a few minutes reviewing the position of electric lighting. The whole industry is at present controlled by the incandescent lamp. We are so accustomed to this, and it is taken for granted in such an unconscious way, that we do not realize how much everything depends on the maker of the carbon incandescent lamp.

In very early days, that is to say in the early eighties, there were a few Edison lamps at 100 volts, with an efficiency too horrible to mention, but the Swan lamp came along, made for 50 volts. I say made for 50 volts advisedly; I mean that the makers tried to make 50 volt lamps, and produced lamps taking from 40 to 60 volts. If the lamps were not bright enough, you ran the engine faster or put a smaller pulley on the dynamo. (The belt then generally slipped, but that is not to the point.) For about four years, which is a long period in the development of such a rapidly growing industry as electrical engineering, the makers of incandescent lamps, or, in fact, the makers of the Swan lamp, decreed that the electromotive force used should be from 40 to 60 volts. There was no appeal. There was no development of central station supply at that time, but still even then in large buildings there was the longing for higher pressures on account of the cost of the mains.

About 1885, the Swan 100 volt lamp came into use. It was a clumsy affair, with little loops of platinum at the sides. At first the lamps were pretty bad, but they gradually improved; and 100 volts, or in some cases 110 volts, became the recognized pressure for electrical supply.

As town lighting from central stations came into being, the limit of 100 volts became a serious trouble, and the evil was partly mitigated by the use of three or even five wire systems. I must point out that the incandescent lamp exercises its tyranny in two ways. It not only insists on a low pressure, such as say 100, and thus demands large leads to feed it, but it is so sensitive to variations of pressure that the system of distribution has to be arranged to give a practically uniform pressure at the terminal of the lamp. The necessity for uniform pressure probably gives more trouble, and costs more than the mere low pressure; and it would be cheaper to supply at 100 volts with a good margin of permissible variation of pressure than supply at 200 with a very small percentage of variation.

Quite lately the incandescent lamp makers have produced things called 200 volt lamps, and some make them for 250 volts. So there is a general tendency on the part of supply companies to jump to a 200 volt supply. The innocent consumer is therefore pressed by the company to change over to 200 volts. The company likes the change very much, and the lamp maker also enjoys it, as he makes more lamps and charges more for them.

Considering the enormous importance of the incandescent lamp, its improvement has received extraordinarily little attention. It limits us as regards pressure, it used to hamper us by its cost, it limits us as to variation of pressure, and it limits us very seriously by its inefficiency. Yet, in spite of these, the carbon incandescent lamp has made practically no advance in fifteen years. Of course mere detail improvement in manufacture has taken place, and this has led to better quality and greater uniformity—hence cheapness; but there has been no radical improvement. The jump to 200 volts from 100, or from 50 to 100, did not depend on any sort of radical improvement in the incandescent lamp; it was merely the result of detail improvements, making it possible to produce long, thin filaments. Other things being equal, it is easy to see that the long thin filaments must be weaker. If the carbon has the same specific resistance, the relation between pressure and length is $E=L^{\frac{3}{2}}$, and $E=D^{-\frac{3}{2}}$. If the filaments are flashed, the proportions will be still more extreme. The question of high pressure incandescent lamps is thus: How far can we make the filaments longer and thinner and flimsier without exasperating our consumers? Unfortunately the consumer is rapidly getting saddened as it is. The 100 volt 8 candle power lamp does not please him much, and the 200 volt 8 candle power lamp has in no way delighted him; if the lamp is made with two 100 volt filaments in series, it combines the disadvantages of both, without the advantages of the small candle power of either. But it adds some further disadvantages peculiar to the higher pressure which I have not so far touched upon, and that is that the higher the pressure, the more troubles there are through the silent discharge, or whatever it is called. I need only refer to the well-known experiment, in which a third terminal is sealed into the lamp. A galvanometer then shows a current going across country inside the lamp. This is no doubt intimately connected with the life, or rather with the death, of the lamp.

I have dealt with the question of high-pressure incandescent lamps at some length, because the subject is really of vital importance, and is too much neglected. Our technical colleges, and our technical press, and technical societies pay the greatest attention to questions of a per cent. or two in the efficiencies of dynamos and transformers, and give a good deal of attention to engines and boilers. That is because there is plenty of room for calculations in connection with these subjects; but the incandescent lamp, which at present holds the whole career of the lighting industry in the little curl of flimsy red-hot carbon that can hardly support its own weight, receives no attention at all. How much does the average electrical engineer know about incandescent lamps? The only subject that is treated in the same way is the cable. About half the money in town lighting goes in the cable, a mere fraction in the dynamos and transformers themselves; so the average electrical engineer knows nothing about cables.

So far I have only discussed the incandescent lamp; the arc lamp has also to be considered. I will not say much about the arc lamp just now, but will add a little more when the Nernst lamp is compared with it. The ordinary arc is limited in pressure to about 50 volts, including the series resistances necessary for regulating. The inclosed arc is a new development, which is more satisfactory as regards pressure and as regards consumption of carbon.

The lamp I describe to-night is the invention of Prof. Walther Nernst, of the University of Göttingen. Though he is a young man, Prof. Nernst's name is already known to all modern chemists as a leading authority and original thinker in the field of physical chemistry. It is unusual for a man who has climbed to the top of one tree to jump to the top of another.

Nernst's, like most great inventions, is exceedingly simple as soon as it is understood. The efficiency of an incandescent body, as far as radiation goes, depends simply on the temperature. The efficiency of an incandescent lamp, for instance, depends on the temperature of the filament only, provided there is no loss by convection. The carbon will not stand a sufficiently high temperature, especially as in addition to its low specific resistance the filament has to be long and slender, and thus weak. Nernst, therefore, chose a material that would stand higher temperatures than carbon, and his material has the incidental advantage that its specific resistance is so high that strong rods can be used for high pressures instead of thin filaments. The most refractory materials so far used in lighting are zirconia, which has been used to replace lime in the limelight, and the oxides or so-called rare earths, in the Welsbach mantles. I am aware, of course, that many people suppose that the Welsbach mantle is not very hot, treating it as if it were at a temperature, for instance, below the melting-point of platinum. The light emitted is supposed to be due to some special power of selective emission due to the oxides employed. I have had a good deal to do with incandescent gas mantles, and I find no reason to suppose there is any magic effect of this sort going on. The part of the flame where the mantles hang fuses platinum wire easily, and very few materials can stand the temperature without fusing or volatilizing. Lime and many other oxides volatilize slowly from the mantles. I do not mean that the mantles are above the boiling point of lime; I have some idea of its melting point, as I have made a few pounds of melted lime and run it out on the floor to look at it. The Welsbach mantles, which are now chiefly thoria, are at a temperature near their softening point, and in the making are raised to a temperature at which they begin to soften.

Nernst takes highly refractory oxides as his material. It does not seem promising, because such oxides are notoriously good insulators. But such insulators are electrolytes when hot. Nernst, therefore, heats the rods to make them conduct, and then heats them electrically, preserving a temperature which is within the limits that the material can bear without softening. This means that he can take the most refractory bodies supplied by the whole range of chemical research, and can heat them to a temperature short of their softening point, and can thus get an efficiency unknown to workers on the incandescent lamp. Such efficiency also means whiteness of light, so long as the efficiency is not too high. Thus the crater of the arc, being at a temperature of boiling carbon, gives a light that is unpleasantly blue.

The material is worked up into little white rods. Each rod is mounted on two platinum wires, a little paste made of refractory oxides being applied to the joints. The little rod with its two wires is then mounted in a holder which fits ordinary electric-light fittings. As the rods fall in resistance so the temperature increases, after the manner of electrolytes, an increase of current produces a decrease of resistance. This tends to give some instability in running in parallel on supply circuits. This instability is corrected, as in an arc lamp which has analogous properties, due to a different cause, by a series resistance. The Nernst rod has therefore a resistance in series. This is made up of exceedingly fine wire, and for ordinary circuits amounts to 10 or 12 per cent. of the whole resistance of the lamp. The consumption, including the resistance, is 1·5 watts per candle for large lamps and 1·6 for small lamps or low pressures. In small or low-pressure lamps the loss of heat at the ends is larger in proportion.

Such a lamp as I have described will not light up of itself, for the rod is an insulator when cold. The simplest way to start it is to warm it up with a match, or better, with a small spirit lamp. Such a lamp as this is not only very cheap as regards first cost, but very economical in running. The life of rods, running at an efficiency of $\frac{2}{3}$ of a candle per watt, including the resistance, is already more than 500 hours in good specimens. If the Nernst lamp advances as much in the first few years of its existence as the carbon lamp did between 1880 and 1882, it will soon be made so well that the rods last a lifetime. When the rod is worn out, a new rod with its wire mounts is all that is replaced. The whole lamp is not thrown away at all.

The method of lighting I have described, though it may be used in many cases, such as large public rooms, is really a savage mode of ignition, fit only for dealing with uncivilized commodities, such as gas and tobacco.

The small lamps and the lamps of medium size are in practice started by a heating resistance. This is arranged close to the rod, and in shunt to it. As soon as the rod is hot enough to conduct, its current works a tiny cut-out in the resistance circuit. In large lamps the heating system is a little more elaborate, as the resistance arrangement is arranged as a sort of hood which covers the rod. As soon as the rod conducts, not only is the resistance circuit broken, but the electro-magnet lifts the little hood clear off the rod. In all these forms, the rod and its mounting are replaceable without interfering with the rest of the lamp.

We have now to consider the part the Nernst lamp is probably going to play in the near future.

Compared with the small incandescent lamps, as you deal with a material of much higher specific resistance, it is easy to give both small lights and high pressures. The question of lighting is exceedingly important, though it appears trifling at first sight. People are so accustomed to lamps being turned on from the door without any further trouble, that they will generally object to having to light them with matches or spirit lamps, but there are many cases in which it will be quite satisfactory to have one lamp with an automatic lighter to show you the way into the room, the rest being lighted with matches or a spirit lamp as needed. There will be, however, a considerable opening for the cheap, small power, high efficiency lamp; and the disadvantage as to lighting is small in such cases as cafés, restaurants, churches, hotels, railway stations, and in short in most public rooms.

Coming now to the next size, that is to say, lamps of 20 to 200 candle power, and even small lamps in which it is worth while to have automatic ignition, the first cost of such lamps will be higher than the first cost of incandescents, but as the rod itself has alone to be replaced, that is a matter of very slight importance. This size of Nernst lamp has, further, every chance of completely ousting the carbon incandescent on the score of cheapness, as to renewals, higher efficiency, better colored light, and perhaps more especially high pressures. Once the Nernst lamp becomes so general that systems of distribution are laid out to suit it, instead of to suit the carbon lamp, the carbon lamp is practically "out of the running." It must be remembered that the Nernst can compete with the carbon filament at any pressure that suits the filament, but the Nernst lamp can easily go right out of the depth of the filament and have the higher pressure to itself. It must be remembered that at present the cost of cables in a system of distribution is an exceedingly large item.

Turning now to the large lamps, they compete with the arc lamp in efficiency. Of course the efficiency of the arc lamp is not a very definite quantity. The candle-power is generally determined by multiplying the current by two and adding zeros at discretion. All I can say is that, however many zeros the good nature of the maker may supply, a Nernst lamp taking the same power gives a better light. When carefully arranged on photometer, the arc may be better in given directions, but a lot of light given in directions that you do not want is not the same as the same light distributed with a uniform spherical emission. The arc lamps shown here will give the audience a good idea of the relative values. The Nernst gives a pleasant, and of course a perfectly steady, light. Coming to costs, the Nernst will be very much cheaper in first cost, but enormously cheaper in maintenance. It also goes quite away from the arc as to pressures; there is no trouble, for instance, in making large lamps to work in parallel at 500 volts and by using double rods at 1,000 volts. This puts an entirely new development of electric lighting in the hands of the engineer.

There is one point I have said little about yet. The incandescent lamp which is still with us gives trouble not only because of the low pressure it needs, but also because it demands that the pressure shall be kept uniform. It seems quite possible that the Nernst lamp may be made to stand a much greater variation of pressure than the filament. If this proves true, it means an enormous difference in the designing of distribution mains. I do not like to say much about this yet, as the invention is too young, and too little time has been available to make much certain progress in that direction. Results are promising, but it is best not to be sanguine.

It is difficult to discuss an invention like this without being carried away by enthusiasm. I feel, however, that I have but feebly shown forth the probable future of what seemed to me the greatest invention in electric lighting that we have seen for many years. Still, I am sure I have not been too sanguine.

[Note.—A diagram and further description of this lamp is published in the current issue of the Scientific American.]

* Paper read before the Society of Arts, February 8, 1899.

**The Reichsgericht**, of Germany, has confirmed the decision of the lower courts declaring the Tesla polyphase motor patents invalid. The court reviewing the case holds that the patents are void, owing to their not having been worked according to the requirements of the German patent law. The court goes on to say, however, that even if the patent had been sustained on that ground, it would have been, nevertheless, invalidated, owing to the fact that the invention was not adequately described in the German patent specification, whereas the American patent specification is clear. It is understood, says The Electrical Engineer, of New York, that the Helios Company, of Cologne, who control the Tesla patents in Germany, will no longer contest the suits which it has brought against several parties in Germany.

## TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

**Utilization of Petroleum Residue.**—The following extracts are taken from a letter from Consul Van Buren, of Nice, dated October 20, to a large petroleum firm of the United States:

Mr. Max Bouchsein, United States consul at Barmen, has reported the invention of a mixture known as "velna," which is manufactured from petroleum refuse, refuse of animal grease or tallow or any other fatty substance, and soda lye. The last number of The British Consular Journal considers the matter of such importance that it calls upon its consular officers to send reports on the subject.

The United States ought to successfully compete in the manufacture of this product. In this section of France, there are several coal mines of inferior quality which are at present useless, but which, with the aid of "velna," could transform their coal into briquettes possessing caloric and gas-making qualities of a high order, and replace the English coal in use here, which costs from $6.50 to $8.50 per ton.

**Bremen Regulations Regarding United States Fruit.**—Under date of December 20, 1898, Consul Lange, of Bremen, says: The very good results of the regulation recently passed by the Bremen senate, regarding American fresh fruits and live plants, which I made the subject of my report of November 3, 1898, are already most perceptible. A shipment of 200 barrels of American apples and 2 barrels of American pears arrived at Bremerhaven a short time ago, and the entire costs for inspecting this shipment by an expert amounted to 8 marks (not quite $2). This should be encouraging news to our dealers in fresh fruits. They should, however, exercise the most scrupulous care in executing orders, and ship none but the very best goods. There is so great a demand for American apples and pears here that they should command good prices.

**Exhibition of Electrical Appliances in Brussels.**—Under date of January 25, Consul Roosevelt, of Brussels, says: At a meeting held January 20 by the Belgian Society of Electricians (Mr. Emile Closset, No. 26 Rue St. Jean, Brussels, president), it was decided to open an exposition of all sorts of electrical appliances applicable to domestic uses. The exposition will be held next May in the new post and telegraph office, Place de la Monnaie, Brussels. It is the purpose of the society to make a complete exhibition of the various uses to which electricity may be applied in the household. Besides appliances for illuminating purposes, there will also be exhibited small motors for operating dumb waiters, cleaning and polishing shoes, heating kitchens, cooking stoves, bathrooms and bath tubs, electric teapots, sad irons, domestic telephones; in fact, all appliances operated by electricity, with a view to the total suppression of the use of coal for domestic purposes.

**American Machinery in Denmark.**—This market offers good opportunities for Americans. Comparatively large orders have recently been placed with our manufacturers, and if they give satisfaction, American machinery and tools will find ready sale in the kingdom. Until now, the Germans have controlled the market. Their prices are a trifle lower than ours, but the superiority of American goods is acknowledged.

There is a market here for engine lathes, drilling and boring machines; milling, planing, and shaping machines; slotting machines, boring and turning mills, radial drilling machines, machines for making screws, punching and shearing machinery, grinding and polishing machines, bolt cutters, and American tools of all kinds.

The largest shipbuilders here, who formerly took their supplies from Scotland, have recently placed orders for plates, angles, etc., as well as the greater part of their forgings for smithy purposes, with American firms, and if these trial orders are satisfactory, an important market will be gained.—Jules Blom, Consul at Copenhagen.

Consul Halstead, of Birmingham, England, also notes at a later date the trade possibilities of Denmark, and he quotes The London Daily Mail, in which it is stated that $50,000,000 worth of business may be secured by English firms, as the Danes are anxious not to buy from Germany, but English firms will not adapt themselves to Danish requirements. This is the old, old story of blind conservatism on the part of England, and here is America's opportunity.

**American Wire Nails in Europe.**—Consul Halstead writes from Birmingham, September 10, 1898: In an article on the manufacture of nails, after showing to what extent wire nails have been substituted for cut nails, The British Iron and Coal Trades Review says that "figures published from time to time make it clear that the United States threatens Europe with serious competition in the nail trade, despite the fact that it is a highly finished product as ironworks products go, and involves the employment of a large amount of skilled labor. At the average wholesale price of $1.08 per keg of 100 pounds, the United States appears to be prepared to sell cut nails at works for about $23, or about £4 15s. per ton—little more than the British price for steel rails. This, moreover," adds The Review, "is not the price for export purposes alone, but the average American price for all purposes for a whole year. We have never heard of any price approaching this figure being quoted in Europe. British nail manufacturers would be likely to find it worth their while to ascertain how it is done, compatibly with the payment of the higher range of wages common to all American industries."

**An Industrial Opening: Crushing of Copra.**—The occupation of the Philippine Islands by the United States suggests the possibility of a transfer to the United States of an industry which is now almost exclusively confined to the city of Marseilles. The crushing of oleaginous seeds and cocoanuts, for the extraction of the oil they contain, has for many years given employment to hundreds of workmen, and the skillful use of blended oils in the manufacture of soap gave to this city its world-wide reputation for the latter. In more recent times, the American cotton-seed oil has to a large extent replaced the copra or cocoanut oil, at the same time severely crippling the seed-crushing business. A soap manufacturer advises me that the cotton oil cannot, however, entirely supplant the cocoanut oil, as the former, if used alone, produces a soap too soft to be acceptable to commerce; and the latter, if unmixed with cotton or peanut oil, makes a soap as much too hard. I am informed that a mixture of about half and half produces the best results, and that the failure of Marseilles manufacturers to maintain these proportions has been followed by a distinct falling off in the quality of some famous brands of Marseilles soaps.

The copra or cocoanuts crushed in Marseilles come almost exclusively from the Philippine Islands. In the year 1897, the imports amounted to 686,120 metric quintals,* in addition to which 31,910 metric quintals were imported from the French colonies. The highest price paid at Marseilles during 1897 was $6.94 and the lowest $5.31. The nuts fall from the trees and lie on the ground until the hard shell separates from the kernel and decays. The kernel appears to lose none of its useful qualities, though permitted to remain on the ground for a year or more. When a favorable opportunity occurs, the copra is gathered, dumped into some small coasting boat, and eventually reaches Marseilles. At the present time, the price is uncertain and almost double the average figure, because of a complete suspension of arrivals from Manila. On January 11 the total stock of copra in the docks and warehouses was only 1,530 quintals, and the fear now prevails that the troubles among the natives will prevent the shipment of any considerable quantity for some time to come.

The assurance that means of communication between the Philippines and the United States will soon be established will make it appear easy for American capital to build and operate crushing mills; and, with cotton oil in unlimited quantities to draw upon, the manufacturers of soap will be in possession of additional resources for carrying on their business.—Robert P. Skinner, Consul, Marseilles.

**Congress for Commercial Instruction in Venice.**—The Department has received a note from the Italian embassy, dated Washington, January 23, 1899, transmitting the regulations for the congress, which will be opened May 4, 1899, in Venice. The regulations prescribe that all persons making application to the committee of arrangements before March 31, 1899, and paying the contribution fee of 10 lire ($1.93) to the treasurer, Mr. Alessandro Berti (Foscari Palace), will become active members of the congress and will have the right to all of its publications. The programme of subjects to be discussed will be decided by the executive council of the committee of arrangements, and will be communicated to all the members at least four months before the opening of the congress. The committee of arrangements will receive suggestions on the programme up to two months before the opening of the congress. Authors are requested to indicate any reforms which might be introduced in commercial instruction. Members can speak in Italian, French, English, and German. Interpreters of the last two languages will assist at the sessions.

**American Goods in Munich.**—Consul Pierie writes from Munich, October 28, 1898: There is a large business in the manufacturing centers of Germany in iron pipes, fittings of all kinds, valves, and engineers' supplies in general. A representative of a number of American manufacturers of the above articles now traveling in Europe reports large sales in Munich and several other German cities. The American methods which have produced hundreds of very successful salesmen in the United States will fail in Europe, where business is far more methodical and access to buyers much more difficult. By far the best plan is to make engagements with the buyer ahead of time. This is usually easy to do. Once the buyer is reached, the salesman has only to sink his and his firm's identity, and admit that the buyer "knows it all." If these points are carefully watched, the actual sale of goods is not difficult. Credits are not necessary. Houses that demand long credits are undesirable, as the great majority are willing to pay cash, if inducements are offered.

Letters and circulars from American manufacturers seem to be increasing at this consulate every day, which shows a disposition on the part of American business houses to find a market for their goods in continental Europe. Munich is increasing in population very rapidly, having at the present time 430,000 inhabitants. It seems to be a first class field for an enterprising American manufacturer. I think there is a good market in southern Germany for boots and shoes, labor-saving machinery of all kinds, and chairs, particularly rocking chairs. I have not seen one of the latter in this city. Canned goods of all kinds from the United States appear to be in fair demand here, and I think quite a large business could be done in this line of goods with proper effort.

**Plows in Italy.**—With a view to the practical demonstration of the advantages of modern agricultural implements, certain interesting experiments were recently carried on at Venice comparing the efficacy of different makes of plows. The experiments were conducted near Mestre under the auspices of the Cattedra Ambulante di Agricoltura di Venezia. Three German firms who maintain representatives in the district, and have been somewhat successful in introducing their manufactures, submitted their plows to the test. The committee in charge arranged the following programme:

1. Deep plowing with single plowshare.
2. Medium plowing with single plowshare.
3. Surface plowing with single plowshare.
4. Work with double plowshare.
5. Work with triple plowshare.
6. Experiments with various implements.

The soil in which the experiments took place consisted of a stratum of clay mixed with sand, ranging below into a composition in which sand predominated. The depth to which the soil had been plowed the previous year did not exceed 7·9 inches, and since then, the ground had not been used. The area available was divided into three sections, one being assigned to each of the firms represented. The first item of the programme was deep plowing, and 13·8 inches was the depth agreed upon. To each plow ten oxen were attached, not because so strong a traction force was actually necessary, but in order to provide against any unforeseen obstacle, and to avoid tiring the animals. U. S. Consul Johnson, of Venice, sent a report of the trials, but as the plows were of German make, they need not concern us here. Trials of this nature are constantly being held abroad, and American manufacturers should be able to compete.

* 1 quintal=220·46 pounds.

**Value of Promptness in Filling Orders.**—Consul Halstead writes from Birmingham, January 9, 1899: A London gentleman interested in railroads in many countries and for several years the president of an American railroad as a representative of British stockholders, has written me, in part as follows:

"I have read the leaders and the extracts from your annual report in the Birmingham papers with more than ordinary interest, for the work is conducive to the advantage and prosperity of both hemispheres.

"One point I venture to suggest, viz., that promptitude in every case will secure business. Recently, I found it expedient to give to United States manufacturers orders for railway engines to be used on roads abroad, because they could be delivered from America in as many weeks as English manufacturers required months to fill them.

"In my opinion, a great revolution in railway management is impending in this country, and it must be brought about on American principles. Cheaper rates, larger cars, and greater rapidity of service are essentials which the trade and traffic of this country must and will impose on the administration of railways, which, in my humble judgment, must adopt a more up-to-date policy if it means to do justice to the requirements of the age."

**American Woods in Germany.**—The import of American woods has steadily increased, although American exporters try very little to comply with the wishes of the German importers. Owing to this cause, more especially in Hamburg, it is probable that business in all consignments from the United States of walnut and oak blocks, planks, and balks results in a loss. A great quantity of inferior walnut woods has reached Hamburg, which, in the judgment of experts, must be sold at a loss; whereas really good material would bring remunerative prices. It appears that, for the last year or so, fashion has dictated the use of mahogany for furniture making, and therefore less walnut (American as well as Caucasian) is asked for; but this is not the sole cause of the decrease. It is rather, as above stated, the low quality of the larger portion of the imports.

Another fault of American exporters is their unreliability in the execution of orders. For instance, in the autumn of 1897 contracts were made for delivery in the spring of 1898, and these are now only partially executed, while the quality of the oak delivered is very inferior. There is a considerable field for American oak, under the following conditions:

1. The assorting must be done more carefully. Woods that are coarse and hard must be described as such in the tenders for supply. Oak woods that are described as first and second qualities must have no splits and be free from the woodworm. The complaint in this respect is general, and American oak, in many cases, cannot be used.
2. The boards and balks must be more carefully (i. e., slowly) dried, thus avoiding dry rot.
3. Exporters must be more prompt in fulfilling their engagements.
4. Sea freight should be kept down as low as possible throughout the year. This might be accomplished by a combination of exporters.

The woods cannot stand a freight of more than 18 cents per 100 pounds to Bremen and 15 cents to Rotterdam. Higher freights prevent a larger import.

Hickory would be much more imported if the exporters would adhere more to the wishes of the market. Split hickory for making spokes is hardly offered at all, although there is always a demand for it.

American cherry makes very slow headway. The beautiful quality of this wood should make it more popular; but the prices asked for it are high.

Red gum is certainly a less valuable wood, but, owing to its cheapness, the inquiry for it steadily increases. It is not advisable, however, to send trunks. Wood with the bark on soon decreases in value. It would be better for the mills to produce large widths for the export trade, because the sending of blocks will then not be necessary.

White gum is a wood that is liked as little here as in the United States. Whoever has used it once does not buy it again.

The consumption of whitewood (poplar) grows steadily, as it is the most suitable material for many purposes, such as carriage making, construction of pianos, etc. Stout blocks of first-class quality are preferred. Small trunks are cut to much greater disadvantage in Germany than in the United States, because higher prices are paid here for large breadths without splits and knots; narrow-board material is obtained cheaper from the United States.

The low-class cottonwood has had a depressing effect on the prices of poplar. Cottonwood is taken in large lots, because people believe that it will serve the furniture makers as blind wood (backing) almost as well as whitewood (poplar).

Maple in balks and blocks does not receive proper attention. In Germany the white maple is liked. This color can be obtained by a careful treatment of the wood, and the effort will prove highly remunerative.

Pitch pine, yellow pine, and Carolina pine have a constant demand. It is highly advisable for United States exporters to take care in sorting. Pitch pine and Carolina pine with blue spunk are very difficult to sell.

Cypress wood is not inquired for in Germany as much as it should be. One disadvantage of cypress wood is that it is so difficult to dry. It is suggested that this is caused by the trees being felled when the trunk is full of sap.

High rates of freight are charged by the railways in Germany for all kinds of American woods. European woods are carried cheaper than non-European woods.—Consul Lange, Bremen, Germany.

**Ties** for the Siberian Railway will be supplied by Japanese lumber dealers to the extent of 4,000,000 pieces at the rate of 1 yen (99¼ cents) each. The ties will be cut in the province of Hokkaido, and are to be supplied at the rate of 800,000 pieces per year.

## SELECTED FORMULÆ.

**Efficient Remedy Against Field Snails.**—A reliable remedy for the extermination of field snails is said to be green vitriol, a quantity which is sold at 30 pfennige (8½ cents) in the drug stores sufficing for 1 ha (2·47 acres). The green vitriol is powdered finely and mixed with dry earth sand, so as to allow of throwing it out as uniformly as possible. The spreading should be done in damp weather or after sun-down. The snails when reached by the powdered green vitriol are sure to perish; they writhe, go into convulsions, and die.—Deutsche landwirthschaftliche Zeitung.

**Production of Liquid Concentrated Hand Cosmetic.**—Same is prepared as follows: Mix intimately 100 grammes of the best pure zinc-white with 100 grammes of the finest talcum, 70 grammes of glycerine, 20 grammes of tincture of benzoin, 10 grammes of extract of heliotrope, and 270 grammes of rose water. This cosmetic is said to be tried, very popular, and cheap. Every white cosmetic without a slight admixture of carmine looks cadaverous, especially at night. A very reliable prescription for liquid cosmetic is the following: Carmine 0·4, talcum 30, precipitated lime carbonate (which may be partly substituted by zinc-white) 70, tincture of benzoin 40, and distilled water 500 to 700, according to the price.—Deutsche Drogisten Zeitung.

**New Process of Tempering Steel in Milk.**—Great difficulties still confront the uniform and proper hardening of steel articles by the methods now in use. Considerable experience is required for hardening scissors, knife-blades, etc., and, withal, the most skillful workman is hardly able to produce a uniform degree of hardness exactly as desired. A Solingen inventor now uses, according to the required temper, milk, fresh or skimmed; whey, sweet or sour; as well as buttermilk, fresh or old. The mixture of the different ingredients of milk with a certain percentage of water also affords an opportunity to employ the hardening medium in a modified degree of effect, so that all requirements can be met. An admixture of water may be used in this connection. The various stages of acidification of the milk are also said to afford a substitute for the usual hardening in oil and other fat-mixtures.—Neueste Erfindungen und Erfahrungen.

**Cement Coatings for Iron Traverses and Articles in Cellars.**—Any good oil paint and minium coating will protect the iron from rust, if it is applied well and has completely dried. If sufficient time is not allowed for the paint to dry perfectly, Schuppenpanzer (scaly coat of mail) and Bessemer paints are of no more avail than the commonest coating of red lead, says the Färber Zeitung. Goslich, therefore, considers a cement coating for traverses, iron water tanks, and other iron articles in the cellar superior to oil paint. Cement dries perfectly in a few hours, and if made right, stands at least as long as oil paint, its cost being equal to nothing. At the experimental brewery in Berlin the hot and cold water tanks are painted with cement, and after four years' time there has been no need of repainting. The T-iron in the new bottle cellar of the experimental brewery likewise had only received a coat of cement.

**Testing Iron Minium.**—According to the Zeitschrift fuer analytische Chemie (xxxvii., 668), H. Banke arrives at the following conclusions, basing on his researches:

In testing iron coatings, consisting mainly of iron oxide ($Fe_2O_3$), it appears necessary to consider the following points:

Iron minium should possess a certain minium percentage of ferric oxide, e. g., at least 80 per centum. In the case of iron minium all ferric oxide is, in spite of strong calcination, soluble in hydrochloric acid, and this reagent may, therefore, be employed as solvent.

In the absence of heavy adulterants, the specific gravity furnishes a means of judging the degree of calcination. A specific gravity of 4·2 is possessed by a material which, as regards chemical properties and price, would be most adapted to the requirements of the trade.

The properties of being acid-proof or weather-proof increase with the specific gravity.

Boiling experiments with diluted acids, like the ones described, may probably, if carried out on a large scale, lead to general testing prescriptions as regards the imperviousness to weather of these coatings.

A finer division of the particles composing the material is of no influence on the property of being acid-resisting. The latter is solely dependent upon the degree of heat in the manufacture.

**Colored Pencils for Sketching on Glass.**—The following are formulas for the composition of pencils for sketching on glass, porcelain, etc.:

1.—BLACK.

| | |
|---|---|
| Lampblack | 10 parts. |
| White wax | 40 " |
| Tallow | 10 " |

2.—WHITE.

| | |
|---|---|
| Zinc white | 40 parts. |
| White wax | 20 " |
| Tallow | 10 " |

3.—LIGHT BLUE.

| | |
|---|---|
| Prussian blue | 10 parts. |
| White wax | 20 " |
| Tallow | 10 " |

4.—DARK BLUE.

| | |
|---|---|
| Prussian blue | 15 parts. |
| Gum arabic | 5 " |
| Tallow | 10 " |

5.—YELLOW.

| | |
|---|---|
| Chrome yellow | 10 parts. |
| Wax | 20 " |
| Tallow | 10 " |

The colors are mixed with the fats in warmed vessels, levigated with the same, and are then allowed to cool until they have acquired the proper consistency for being transferred to the presses. In these the mass is treated and shaped similarly as the graphite in the presses for ordinary pencils.—Pottery Gazette.

## THE TRANSCASPIAN RAILWAY.

The railway which has been constructed by Russian engineers between the Caspian Sea and Samarkand is in many respects one of the most remarkable undertakings in the world. First and foremost, it passes for a great part of its length over a country which is little more than a sandy desert. In the second place, it owes its inception and its success to a single individual. And, thirdly, it comprises some engineering features which in themselves merit special undertaking.

The country between the eastern shore of the Caspian Sea and the River Oxus was the last portion of Central Asia to come under Russian rule. This country, occupying an area of 214,000 square miles, was formed into the government of Transcaspia in 1874. Its features are few and uninteresting. Without an appreciable elevation in its whole extent, the arid steppe stretches everywhere to the horizon without a relieving upland, and the center of the district, separating the Caspian from the Aral Sea, is a dreary desert devoid of vegetation, known as the Kara Kum. Along the southern border of Transcaspia is a range of mountains serving as a frontier to the dominions of the Shah, and along their base at varying intervals are small settlements, formerly forts, or, at least, fortified auls, useful to the Turkomans, who used to ply their trade of robbery throughout the country against any travelers and caravans which chanced to come their way.

The acquisition of the central Asiatic Khanatz gave Russia a strong interest in Khiva, Bokhara, and Kokhand, but the greatest difficulty was experienced in maintaining communication with them owing to the far-reaching deserts by which each was parted from civilization. When Kokhand was annexed in 1876, and the province of Feyhand created, the military authorities began to discuss the desirability of constructing a railway to connect that distant corner of the world with St. Petersburg, a number of schemes were mooted and subsequently abandoned, the most favored scheme being a line to run direct from Orenburg to Tashkent. In 1882 the Transcaucasian Railroad from Baku to Tiflis was opened for traffic, thus bringing Baku in communication with the existing line to Batoum. This placing of the Caspian in direct connection with Europe served to suggest a continuation across the steppes of Central Asia, and the idea was supported by the great difficulties which had been experienced in transporting the Russian expeditions of Lomakin and Skobeleff across the Turkoman Desert. Among the officers who accompanied the latter in the infamous expedition against Geok Tepe was the late General Annenkoff, who acted as Controller of Military Transports, and before the campaign was over he suggested a railway from Krasnovodsk, the base on the Caspian, and Kizil Arnat in the Tekke Oasis. After much discussion the scheme was approved and entrusted to Annenkoff for execution.

The work of construction was commenced in 1880, and by the beginning of 1881 the line was opened as far as Kizil Arnat, a distance of 144 miles. The second stage of 146 miles to Askahad was pushed on apace, and the Oxus was reached in December, 1886, the distance being 659 miles, the journey hence to Samarkand being 241 miles, or 900 in all. The town of Chardjui, where the railway crosses the river to-day, was for a long time the terminus, and the difficulties experienced in carrying the road across the Oxus, which is at this point 2½ miles wide, were considerable. The work was eventually accomplished by means of a series of bridges resting on dams, the first being 5,740 feet and the others from 200 to 560 feet in length. The bridges are of wood, resting on piles sunk in the river bed, and the whole of the material had to be brought from Russia, there being no timber to be found in Central Asia.

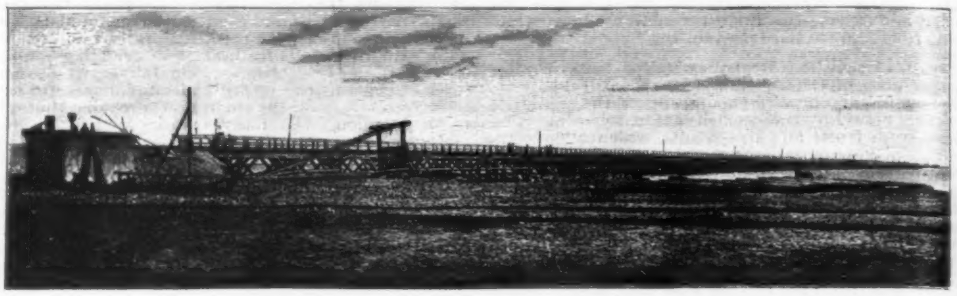
When first opened, the Transcaspian Railway started from the Caspian at a place called Oozoon Ada, near Mikhailovsk, but in 1896 a fresh terminus was made at Krasnovodsk, 48 miles away, as being a more convenient spot on account of its superior harbor accommodation. After skirting the sand dunes which encumber this part of the Caspian coast, after emerging from these, one catches the first sight of the Kopel Dag Mountains, which continue in serried lines as far as Askahad, 300 miles away. Hence the railway runs in a southeasterly direction, with stations every 10 miles or so, and nothing to relieve the monotony of the eternal flatness around.

The first stopping place of any interest at which the two storied lumbering trains pull up from their jog trot of from 10 to 14 miles an hour is Kizil Arnat, noteworthy as being the base of the railway and site of its engineering department. The town is situated at the beginning of the Akhal Tekke Oasis, and is surrounded by a fertile district of small extent.

Geok Tepe, three-quarters of the distance from Kizil Arnat to Askahad, is notorious as having been the scene of the hideous massacres of General Lomakin in 1879 and Skobeleff in 1881. It was here that the latter butchered 8,000 Turkomans, about half of whom were women and children.

Askahad marks the end of the Tekke Oasis, and shortly after passing it the mountain range ends and one enters the Tedjent district, in which the line makes a sharp bend and turns northeast in the direction of Merv. The capital of Turkomenia lies in the midst of an oasis of small extent which is watered by the River Murgab. It is bordered on the one side by barren steppes and on the other by a sandy desert. The modern town has been entirely built by the Russians, the old inhabitants, all of these nomad Turkomans, having lived in tents which they took up and moved away from time to time. The place is rapidly developing and becoming an important place, besides being noteworthy as the nearest town of any size to the Afghan frontier. The place is decidedly unhealthy; tropical in summer and arctic in winter, it is occasionally devastated by the flooding of the Muyah, and the lack of good drinking water gives rise to much disease.

From Merv to Chardjui, on the bank of the Oxus, is 147 miles. Across the bridge one enters the Khanah of Bokhara proper, and at 66 miles from the river the train stops at its ancient capital. The valley of the Zarafshan, in which Bokhara stands, is a welcome relief to the traveler who has traversed the arid steppe and desert all the way from Krasnovodsk. It is known



BRIDGE OVER THE OXUS (AMU-DARJA).

RAILWAY STATION, SAMARKAND.

as the most favored region in Turkestan, and fully accounts for the prosperity which has always distinguished the khanah.

From Bokhara the railway follows the river, passing out of the river's territory at Sari Bulat, and entering Russian territory once more at Kati Kurgan, whence a run of 50 miles brings one to Samarkand, the present terminus of the line. The station at the ancient city of Tamerlane is, like those at Bokhara, Merv, and Askabad, quite a fine specimen of oriental work. The convenience afforded at these important places is, however, fully discounted by the lesser halting places, which are, without exception, very poor in accommodation. The town is one of the quaintest in Central Asia, and every part of it has its reminiscences of the troublous times through which the country has passed.

VIEW OF KRASNOVODSK.

The tomb of Tamerlane is in ruins, but retains a semblance of its former grandeur. The people of Samarkand are a mixed lot, comprising Hindus, Uzbeks, Kirghiz, Persians, Khivans, Bokhariats, Jews, Turkomans, Afghans, and Russians. The latter amount to about one-sixth of the population.

The future continuation of the Transcaspian Railway is still undecided. It is already nearly completed to Tashkent in one direction (131 miles) and to Andidjan (333 miles) in another, and it is believed that from Tashkent it will be prolonged through Semipalatinsk to Omsk, when it will effect a junction with the Siberian Railway, while the Andidjan branch will be continued to Kashgar, whence it will eventually join the Northern China Railway via Lancheo and Figan. The cost of this remarkable railway has been roughly $12,000,000, or about $15,000 a mile, a cost which, regarding the difficulties of the route, cannot be deemed at all high.

Among the troubles of construction, the greatest was

IMPERIAL CARRIAGES ON THE TRANSCASPIAN RAILWAY.

the constant shifting of the sand in the deserts, which not only rendered progress extremely difficult, but buried the road as fast as it was made. The late General Annenkoff, who, besides being in charge of the line, took an active part in its construction, met this difficulty in two ways. Finding that the transport of the heavy material required would render the employment of horses, or even camels, very costly, he laid down a steam tramway over the worst portions of the route, and thus provided an easy means for conveying the rails, etc., to the front. The first section of railway ever laid down in Central Asia was constructed in 1880, when 17 miles of road were laid within ten days.

To attempt to fix a shifting desert of sand is an undertaking which might well appal even an expert engineer; but General Annenkoff proved himself equal to the occasion. He tried various hardy lichens which will grow in the desert, in the hope of discovering one which would bind the sand together with its roots, and after a series of experiments he chose a species of shrub known as saxaoul, which has been planted in millions over the sandy tracts, but more especially in the terrible sun-baked desert which lies between the Merv Oasis and the Oxus. The saxaoul does its work very well, and suffices to keep the sand from drifting on the line sufficiently to interfere with the traffic, except here and there, where fences of wood are erected alongside the track to shelter the railway from the storm. The difficulties of construction were accentuated by the climate, which tried the workers severely. Many died from sunstroke. Some perished from thirst. Numbers of the engineers had to resign their appointments; but Annenkoff stuck to it through all, and succeeded in bringing his scheme to a successful issue.

And successful it is, in the highest degree. Not only is the Transcaspian Railway a valuable strategic line which will prove invaluable for the transport of troops in case of need, but it is already serving a useful purpose in its tendency to educate the Turkoman and Kirghiz tribes, through the former of whose territory it passes, and at the same time tends to develop the trade of the Central Asian oases and khanahs. Beyond all these considerations there is another point which goes a long way toward indorsing the opinions originally expressed on the subject by General Annenkoff. The point in question is to be found in the fact that the line is being worked at a profit; it paid its expenses from the very first. In 1890 it showed a profit on the working for the year of three per cent., and today promises to double that.

There is one feature about this railway which possesses extreme interest for Englishmen. The southernmost point of the line is only 238 miles from Herat, and the station at Tejend would doubtless, in the event of a war between Russia and Great Britain, become the base for any operations directed against India.—Alexis Krausse in Black and White.

## ABSTRACT OF REPORT OF THE COMMISSIONER OF PATENTS TO CONGRESS, FOR THE YEAR ENDING DECEMBER 31, 1898.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
Washington, D. C., January 31, 1899.

To the Senate and House of Representatives of the United States of America in Congress assembled:

In compliance with Section 494 of the Revised Statutes, I have the honor to submit the following report of the business of the Patent Office for the year ending December 31, 1898:

### SUMMARY.

In 1898 there were received 33,915 applications for patents, 1.843 applications for designs, 84 applications for reissues, 1,659 applications for registration of trade marks, 316 applications for registration of labels, and 50 applications for prints. There were 22,207 patents granted, including designs, 60 patents reissued, 1,238 trade marks registered, and 200 labels and 35 prints. The number of patents that expired was 15,548. The number of allowed applications awaiting the payment of final fees was 6,824. The number that was forfeited for non-payment of the final fees was 4,363. The total expenditures were $1,136,196.20. The receipts over expenditures were $1.538.28. The total balance to the credit of the Patent Office in the Treasury of the United States on January 1, 1899, was $4,972,976.34.

In proportion to population, more patents were issued to citizens of Connecticut than to those of any other State—1 to every 933 inhabitants. Next in order are the following: Massachusetts, 1 to every 1,428; Rhode Island, 1 to every 1,584; New Jersey, 1 to every 1,594; District of Columbia, 1 to every 1,694; Montana, 1 to every 1,723; Oklahoma, 1 to every 1,819; New York, 1 to every 1,825; Colorado, 1 to every 1,865; California, 1 to every 1,951. The fewest patents granted in proportion to the number of inhabitants were in the following States: South Carolina, 1 to every 23,982; North Carolina, 1 to every 22,787; Mississippi, 1 to every 18,964; Alabama, 1 to every 18,914; and Georgia, 1 to every 17,333.

### THE WORK OF THE OFFICE.

In entering upon the duties of this office on February 5, 1898, I found that the work of the office was largely in arrears. For years my predecessors had forcibly urged an increase in the number of examiners and a slight increase in the clerical force. Realizing the absolute necessity for such increase, your immediate and favorable action was earnestly requested. Impressed with the justness of the plea of the inventors and manufacturers for a more prompt service, you gave the increase of force asked for, with the result that for the first time for at least ten years it is unnecessary for a Commissioner of Patents in his Annual Report to plead for an additional force.

The result has justified your action and my predictions. On December 28, 1897, 11.382 applications were awaiting action, and by March 15, 1898, the number of such applications had increased to 14,842. On December 27, 1898, the number of such applications had been reduced 5.915 from the number awaiting action December 28, 1897, and 9.375 from the number awaiting action March 15, 1898, so that only 5,467 applications were then awaiting action. Of this number only 2,999 were applications which had not received any action, as against 7.858 applications awaiting their first action on December 28, 1897, and 10,720 such applications awaiting action on March 15, 1898.

Many of the examining divisions on December 28, 1897, were from four to six months in arrears, while on December 27, 1898, only one division was in arrears over six weeks, and that division has since come within the six weeks limit, while all amended cases are taken up for action within fifteen days after amendments are filed. The condition of the examining work of the office on the respective dates—December 28, 1897, and December 27, 1898—is best shown by the weekly reports of those dates.

### THE EFFECT OF THE WAR UPON THE BUSINESS OF THE OFFICE.

It is but fair to state that one of the elements contributing to the reduction of the number of applications awaiting action at the close of the year was the falling off in the number of applications received during the last nine months of the year. This was owing largely to the war. The rank and file of our army was largely made up from the ranks from which, to a large extent, our inventors come. An examination of the records of the office shows that the civil war brought about a similar very large reduction in the number of applications filed during that period. In 1860, 7,653 applications were filed, while in 1861 the number fell off about 40 per cent., being only 4,643. It was not until in 1865 that the number of applications filed rose to and passed the figures of 1860. While the reduction in the number of new applications received during the past year has been a factor in bringing up the work of the office, the fact must not be lost sight of that the increase in force was not available until in July, and that while no better equipped force of young men has entered the service of the Patent Office than the twenty-eight additional examiners who were added to the force last July, yet necessarily, being new to the work, their efficiency for the first six months was much less than it will be from now on. That this is so is shown by the fact that at the time of presenting this report over one-third of the examining divisions are engaged in examining new cases filed less than one month ago. I cannot speak too highly of the interest taken by the examining corps in bringing up the arrears of work. When required, the examiners have cheerfully worked until five o'clock, and often later. There is not a more enthusiastic or loyal force in the employment of any branch of the government service than is to be found in this office.

The salaries paid to members of the examining corps are inadequate, and this is shown by the fact that every year more and more of the most efficient examiners resign.

The work of the clerical divisions is well in hand. Assignments are recorded within fifteen days from their receipt; copies of official records are furnished with promptness, and printed copies of specifications

and drawings of patents, while, for reasons hereafter stated, are not furnished as promptly as should be, yet the delay is much less than before the addition to the number of our messenger boys was granted.

### THE CLASSIFICATION DIVISION.

For a number of years my predecessors urged an increase of force in order to establish a classification division. Such a division was authorized by the act of June 10, 1898. Preliminary to the establishing of the division reports were called for from the members of the examining corps, and their experience enabled them to make valuable and practical suggestions, which so far as possible will be utilized. The division has been established and placed in charge of a chief, to whom has been assigned a sufficient force to commence to revise and perfect a classification of all letters patent and printed publications in the United States Patent Office, which constitute the field of search in the examination as to novelty of the inventions for which applications for patents may be filed, and that force will be increased as rapidly as the best interests of the work in hand demand. The necessity for this work is manifest. It is a work of great magnitude, for the field of search is enormous; over 620,000 United States patents have been issued, while the issue of foreign patents is approximately 1,200,000. Of the latter, about twenty per cent. is not available for the use of the work in examination, for the reason that we are only furnished with the titles of that per cent. of the patents. However, sixty-one per cent. of the foreign patents are fully available for examination, being published in full, and, with the exception of Finland and Portugal, are accompanied by drawings. Sixteen and one-half per cent. are partially available for examination, being published in abstracts.

The number of technical journals and scientific publications relating to the industrial arts from which searches, if they are to be complete, must be made is very large. As long as a preliminary search for novelty is to be made it is of vital importance that it should be thorough, but without a complete classification of the prior art as illustrated in patents and scientific publications it cannot be complete. In the annual report for the calendar year 1899 this office will be able to submit in detail the system of classification adopted. As yet the work has not progressed far enough to enable us to determine the details of the best system to be adopted, in view of the force available for the work.

### THE NEEDS OF THE PATENT OFFICE.

The most pressing need of this office at the present time is for additional room. It is expected that in a few months some additional room will be placed at our disposal, but I seriously question whether such room as may become available and be assigned to the Patent Office will be adequate for the needs of the office. Room sufficient for the use of the examining divisions may be provided, but as our records are rapidly accumulating, especially the printed copies of patents, it is manifest that it will require the entire Patent Office building, if sufficient and convenient room be had for the use of the examining and clerical divisions and for the convenient and safe arrangement of our records.

At the present time the cost of furnishing printed copies of the specifications and drawings of patents is double what it would be were these copies conveniently and accessibly arranged, and without such arrangement the delay incident to furnishing these copies, by reason of their being scattered throughout all parts of the building, will continue. These copies should be furnished with the same promptness as a yard of cloth may be had at a store. The price charged for them is at least equal to their cost to us, and the purchaser is entitled to prompt service, which in many cases is of the utmost importance. Were room provided for the convenient and accessible storage of these copies, a force smaller than that now employed would be sufficient to promptly fill all orders. The Patent Office is patiently waiting for the promised relief, and it is hoped that when the relief comes it will be found adequate, and that future reports will not reiterate oft-repeated demands for sufficient room to enable this office to properly discharge its varied functions.

### STENOGRAPHERS AND TYPEWRITERS.

The next most urgent need is for skilled stenographers and typewriters. In numbers the clerical force of this office is about sufficient at the present time to perform the work required; but the trouble is that many of the clerks entered the service before stenography and typewriting became a necessity. For example, assignments have been recorded in longhand in this office for years. Within the past few months experiments have been made with book typewriting machines which satisfactorily demonstrate that with these machines and skilled operators not only a smaller force can do all the work of recording and in a much more satisfactory manner, but what is also of moment in the crowded condition of the office, a saving of space required for the storage of the record books of about forty per cent. could be made. Furthermore, every examining division should have at least one skilled stenographer and typewriter, and all copies of office records should be typewritten. Notwithstanding the technical nature of a large part of the work required of stenographers and typewriters in this office, Commissioners have tried in vain to induce Congress to pay our copyists the same salaries paid in other departmental offices. Many of our copyists receive only $720 for the same service for which copyists in other departmental offices receive $900. The expected results from this: After a few months' service in our office many of our best stenographers and typewriters are enabled to secure transfers to offices where the smallest salary paid to copyists is $900. The position of training school is not enviable, and it is not just to this office to so adjust salaries that that result must necessarily follow.

### SCIENTIFIC LIBRARY.

The value of this library has been repeatedly and forcibly set forth by my predecessors. The annual appropriation for this library has for years been inadequate. I have submitted a proposition to Congress which, if favorably acted upon, will materially strengthen the condition of the library without requiring any additional expenditure of money. Authority has been asked to dispose of such works in the library as are not necessary for the work of the office, with permission to use the avails thereof in the purchase of modern works. It is hoped that this authority will be granted.

### ALPHABETICAL LIST OF PATENTS FROM 1790 TO 1873.

For several years this office has contemplated publishing a general index or alphabetical list of patentees from 1790 to 1873 as a companion to the subject-matter index of patents for inventions from 1790 to 1873, hitherto published, and which, with the annual indexes published since the latter date, will complete the alphabetical list of all persons who have obtained patents since the foundation of the government. Most of the matter necessary for the production of this work has been prepared and is ready for the printer. There is an urgent demand for the work, and if the index could be printed by contract, the money received would pay the cost of printing it; but when we are compelled to have this work done by the government printing office, the estimate of cost is so great that I cannot in justice to the Patent Office bring myself to the point of asking an appropriation for the purpose. The estimate of the government printing office for doing this work is over $32,000, while the estimates furnished by responsible parties show that by contract this work could be done for about one-half of that sum. I ask authority to have this work done by contract. In this connection I desire to call attention to the fact that this office annually pays to the government printing office between $250,000 and $300,000 for printing and binding. This work could be done by contract for a sum not exceeding $200,000, and I cannot but feel that this saving ought to be made. The printing and binding for this office should be done by contract in Union offices.

### DESIRED LEGISLATION.

The following amendments to the patent and trade mark laws are recommended:

1. An amendment providing for the appointment of Commissioner and Assistant Commissioner of Patents for a stated term, which should not be less than six years.

The duties they are called upon to perform are largely judicial in character. The Supreme Court of the United States in the recent case of United States, ex rel. Alfred L. Bernardin, v. Charles H. Duell, Commissioner of Patents, said:

"Now, in deciding whether a patent shall issue or not, the Commissioner acts on evidence, finds the facts, applies the law, and decides questions affecting not only public but private interests; and so as to reissue, or extension, or on interference between contesting claimants; and in all this he exercises judicial functions."

A definite term will give a stability to the office practice which is sadly needed. Since 1870 there have been fourteen Commissioners, or, in other words, a new Commissioner about every two years.

2. An amendment to limit the life of all patents so that they shall expire not later than twenty years after the applications for the same are filed.

At the present time it is possible to keep applications alive for an indefinite number of years. That this practice does not promote the progress of invention is self-evident.

3. An amendment permitting aliens to file caveats.

By so doing we may hope to receive certain important concessions from some foreign countries.

4. An amendment providing for the publication of 3,000 copies of The Official Gazette of the Patent Office to be apportioned among senators and representatives in Congress, by them to be distributed among manufacturers and mechanics.

At the present time 7,000 copies of The Official Gazette are printed, and it is believed that 3,000 additional copies can be furnished for a sum very little in excess of that now paid for the 7,000 copies.

5. A statute to provide for the registration of trade marks used in interstate commerce.

I am informed that the commission appointed by the President on July 7 last, under the act approved June 4, 1898, "to revise the statutes relating to patents, trade and other marks, and trade and commercial names," which consists of Judge Peter S. Grosscup, Hon. A. P. Greeley, and Mr. Francis Forbes, will in connection with their report to your honorable bodies submit a proposed trade mark law which will provide for the registration of trade marks used in interstate commerce. I cannot commend that feature too strongly, and trust that the act when introduced will receive immediate and favorable action.

6. An amendment providing a fee of five dollars for petitions in interlocutory proceedings to the Commissioner of Patents.

Other amendments will hereafter be suggested; but in view of the lateness of the session, no good purpose would be subserved by extending this report, and therefore they are omitted.

### THE REASONABLE REQUESTS OF INVENTORS AND MANUFACTURERS SHOULD BE HEEDED.

When it is remembered that this office is more than self-sustaining and that American inventive genius has cheapened the cost of production to the advantage of American wages, it seems as though the legislative branch of the government has done very little to encourage the useful arts and the inventors of the country. At the present time, when our manufacturers are reaching out for foreign markets, I believe no greater aid can be given them than by fostering and stimulating invention. The United States can only become dominant in the markets of the world through labor saving inventions which will enable it to compete with the lower wages paid to the so-called working classes in other countries. The greatest development in American exports must be in the direction of increase in the export of manufactures. I assert, without fear of successful contradiction, that we mainly owe to our patent system such foothold as we have gained during the past fifty years in foreign lands for our manufactured products. We can, by a fair and liberal treatment of our inventors, control for our manufacturers not only our home markets but the markets of the world. In the words of a recognized authority, "in labor saving machinery and in the intelligence of the labor employed, the United States to-day is in advance of the world." Most labor saving machinery perfected within the last seventy-five years is the invention of our own people. The reaping machine, which from 1861 to 1865 did the work of more than a million men working with hand implements, is of American origin. The same is true of the modern plow and its added improvements, of the corn planter, and the thrashing and separator machines. In the textile industry the American record surpasses that of all other countries. Wool carding machinery owes its chief improvement to the invention of John Goulding, whose patent was issued in 1826, which dispensed with the splicing billey, and produced the endless roll or sliver. The Crompton loom for weaving fancy woolens and the Bigelow loom for weaving carpets are of American invention. It is not alone by fundamental inventions that our inventors have revolutionized in so many respects the textile industry. Not the less have their inventions in automatic devices, in expediting processes, and in many steps dispensing with hand labor assisted in placing this country in the front ranks in the textile art. Another marked illustration is found in the steel industry, where the reduction in manual labor has enabled our manufacturers to successfully compete with foreign nations. American electrical appliances command the world's markets. This subject is somewhat trite, and I have only referred to a few well known historic facts for the purpose of emphasizing the advantages that will certainly flow from recognizing the just claims of our inventors. Let us not forget that it is the American inventors who by their inventions and discoveries "have made the last fifty years of the nineteenth century the most remarkable of recorded time" and at the same time have laid the civilized world under tribute to American manufactures.

In return for all this our inventors only ask a fair field and fair treatment. They only ask that the money paid into the treasury by them shall be used, so far as necessary, for the purpose of providing necessary facilities for prompt and intelligent action upon their applications for patents for their inventions. They ask no subsidies. They give more than they take. An enlightened public sentiment demands that their requests should be considered with favor by the Congress of the United States.

Respectfully submitted,

CHARLES H. DUELL,
Commissioner.

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[Continued from SUPPLEMENT, No. 1209, page 19389.]

## THE ECONOMIC STATUS OF INSECTS AS A CLASS.*

### AS DESTROYERS OF NOXIOUS PLANTS.

JUST as we have shown how important is the rôle played by insects in the destruction of cultivated and useful plants, it will be easy to indicate their importance as destroyers of weeds and other noxious plants. We need only mention the common and cosmopolitan thistle butterfly (Pyrameis cardui), the equally common milkweed butterfly (Anosia plexippus), the purslane caterpillar (Copidryas gloveri), the burdock beetle (Gastroidea cyanea), and the purslane sphinx moth (Deilephila lineata) to recall to the mind of the experienced entomologist many other species which do similar work. They are here, as in the former case, perhaps the principal agents in preventing the undue increase of any one species of plant, but as we find here not an effort of man to combat Nature, as it were, by increasing the growth and spread of one species at the expense of the others, but the exact opposite, so, here also, to a degree we find Nature arrayed against man, and insects thus play by no means the same part in the destruction of weeds that they do in the destruction of cultivated crops. Nevertheless, they have an important function in this direction, and it is safe to say that the benefit which the agriculturist derives from their work in this way is very great. As long ago as the beginning of the century it was pointed out by Sparrman that a region in Africa, which had been choked up by shrubs, perennial plants, and hard, half-withered, and unpalatable grasses, after being made bare by a visitation of destructive grasshoppers, soon appeared in a far more beautiful dress, clothed with new herbs, superb lilies, and fresh annual grasses, affording delicious herbage for the wild cattle and game.

In a similar way Riley has called attention to the fact that after the great grasshopper invasions of Colorado and other Western States in the years 1874 to 1876 there were wonderful changes in the character of the vegetation, the grasshopper devastations being followed by a great prevalence of plants which in ordinary seasons were scarcely noticed. It is true that some of these plants were dangerous weeds, but others were most valuable as forage for the half-starved live stock. Moreover, other plants, and especially short or recumbent grasses, took on a new habit and grew luxuriantly; one species, for example, Eragrostis poæoides, ordinarily recumbent and scarcely noted, grew in profusion to a height of three and a half feet.

An important, but not generally realized, benefit which is derived from the insects may be mentioned under this head, though not strictly belonging here. Kirby showed, seventy-five years ago, that the insects that attacked the roots of grasses, such as wireworms, white grubs, etc., in ordinary seasons only devour so much as is necessary to make room for fresh shoots and the product of new herbage, in this manner maintaining a constant succession of young plants and causing an annual though partial renovation of our meadows and pastures, "so that, when in moderate numbers, these insects do no more harm to the grass than would the sharp-toothed harrows which it has sometimes been obliged to apply to hidebound pastures, and the beneficial operation of which in loosening the subsoil these insect borers closely imitate."

### AS POLLENIZERS OF PLANTS.

It can no longer be doubted that cross fertilization is one of the very most important elements in the progressive development and continued health of the great majority of flowering plants, and, indeed, that it is with some almost a condition of existence. Opposition to this view, at no time especially strong since the publication of Darwin's great work, has become

* By Dr. L. O. Howard. Address of the retiring President of the Biological Society of Washington, delivered January 18, 1899.

feebler and more feeble until at the present it is not worth considering.

Comparative experimentation with self-fertilizing and cross-fertilizing plants, repeated with many species and genera, have shown a superior growth and vitality on the part of those subjected to cross-fertilization of such a degree as to leave not a semblance of a doubt; while in individual cases self-fertilization has been scientifically shown to even result in a deterioration so marked that it has been compared to poisoning.

In this condition of affairs it at once becomes evident that the good offices of insects in this direction are of incalculable importance, since it must be plain that of the natural agencies by which cross-fertilization of plants is accomplished, insects are far and away the most prominent. Every investigation which has been undertaken of recent years, and activity in this field is increasing by leaps and bounds, has shown the most marvelous adaptations between the structure of flowers and the structure of their insect visitants, all in the line of facilitating or really enforcing the collecting and carriage of pollen by flower-visiting insects from one plant to another. An estimate of the numbers of the species of insects engaged in this work would include the forms belonging to whole families and almost orders, and if we could imagine the race of flower-visiting insects wiped out of existence, the disastrous effect upon plant growth would be beyond estimate. I am not prepared to state that insects benefit plants in this way to such an extent as to overcome the results of the work of the plant-destroying species, but if it were possible to compare in any way the results of these two classes of work, it is safe to say that the effect would be surprising.

We must, therefore, without going further into detail, place this pollenization of plants as one of the very most important beneficial functions of insects in their relations to man.

AS SCAVENGERS.

Another beneficial function of insects, the importance of which can hardly be overestimated, is their value to humanity in doing away with and rendering innocuous dead matter of both plant and animal origin. This subject has never been discussed without reference to the famous statement by Linnæus that the offspring of three blowflies would destroy the carcass of a horse as quickly as would a lion; and while the exact statement in its details is open to doubt, still it serves to illustrate, in a striking way, the good offices of insects, and it is certainly true that after the offspring of the blowfly have finished with the horse's carcass this would be left in a much less offensive condition than after the departure of the lion.

There are inhabited regions in which the climate is so dry that dead bodies of animals never become offensive, but, by natural mummification, remain simply as cumberers of the earth. In such regions insects play little part. Wherever, however, there is sufficient moisture to produce a natural decay, there insects occur in swarms and hasten the destruction of the decomposing mass in a marked degree. Were the bodies of dead animals not destroyed by insects in this way, and, still more, were the destruction of dead vegetation not hastened as it is by the attacks of countless insects, it is perfectly easy to see that the earth would not be inhabitable, its surface would be covered with the indestructible remains of what was once life in some form.

Large groups of insects, comprising many thousands of species, take part in this inestimable work, and it will probably be unnecessary in order to bring about a realization of this value to dwell further upon the subject.

AS MAKERS OF SOIL.

It is a fact not generally realized that insects must take an important part in the changes in the character of the soil which are constantly going on. Occurring in such countless millions as they do, constantly penetrating the soil in all directions, frequently dragging vegetation below the surface and bringing the subsoil up to the surface, changing the character of the soil humus by passing it through their bodies, and fertilizing the earth by their own death and decay, it is probable that insects are responsible for even more soil change than are the earth worms, which Darwin has placed before us in such an important light.

Insects are found beneath the ground in incredible numbers; some of them pass their whole life underground, feeding upon roots and rootlets, upon dead and decaying vegetable matter, upon soil humus and upon other insects; many of them have their nests underground, although they get their food elsewhere; while others hide their eggs or pupæ underground.

The depth to which they penetrate is something surprising; the minute insects of the family Poduridæ have been found swarming literally by the million at a depth of six to eight feet in a stiff clay subsoil.

AS FOOD AND CLOTHING AND AS USED IN THE ARTS.

In this rôle insects play an important part. Insects as food, and their products as clothing, are well known to all. The great silk industry of the world is derived wholly from insects, and almost entirely from a single species, the silkworm of commerce.

As food, insects have formed articles of diet for certain savage peoples since the beginning of the human race. Hope, in 1842, catalogued forty-six species of insects used as food, and Wallace, in 1854, showed that insects of six different orders were used as food by the Indians of the Amazon. Semi-civilized peoples to-day use certain insects as food, as witness the consumption of Corixa eggs by the Mexicans, and a book has been written under the caption "Why not eat insects?" for the purpose of showing that many possibilities in the way of dietetics are being ignored to-day. M. de Fontvielle, in addressing the Société d'Insectologie, in 1883, expressed regret that the attempts made to popularize the use of insects as food have made so little progress, and said that we ought not to forget the remark of the Roman Emperor who said that the body of an enemy never tasted bad, and that the banquet of the society would always lack something so long as there was not placed before them at least some grasshopper farina and fried white worms.

A single insect, the honey bee, furnishes a notable article of food, and is the basis of a great and world-wide industry.

As food for poultry, song birds, and food fish, insects are indirectly of great benefit to man. Not only do they provide living food for such animals, but Corixa mercenaria, a water bug, is now being imported by the ton from Mexico into England as food for birds, poultry, game, and fish. One ton of these bugs has been computed by Mr. G. W. Kirkaldy to contain 250,000,000 of insects (Entomologists' Monthly Magazine, August, 1898).

In the days of pure empiricism in medicine, insects were used extensively, and we have only to mention the Spanish fly to show that they are still of some value.

In the arts, shellac and Chinese white wax, as is well known, are insect products, as also are the formerly greatly used cochineal dye and Polish berry dye, the so-called berry in this case being an insect and not a berry.

The last-named instances are all derived from scale insects, a group of astonishing capacity for multiplication, the commercial possibilities of which are by no means exhausted, as I took pleasure in showing in a paper read before the American Association for the Advancement of Science in 1897. It should be noted here, also, that there is good reason to believe that the manna of the Bible, upon which the Children of Israel subsisted while in the wilderness, was also the secretion of a scale insect.

SUMMARY OF THE HABITS OF INSECTS.

After this general account, arranged under the classes of damage and classes of benefits brought about by insects, it will be well to attempt an arrangement of the subject in a somewhat different manner, in order to gain, if possible, some light as to the relative proportion of insects which are injurious or beneficial.

It will be manifestly impossible to catalogue the species or the genera in this way, and it will be obvious that a classification from families will be lacking in exactness, since some of the families are very large in number of species and others exceedingly small; but, taking the groups as a whole, no better and speedier means suggests itself than to summarize the habits by families.

Another difficulty, however, which arises in such a classification is the fact that some orders are in a much more advanced stage of classification than others, and the force which is given to a family as a taxonomic group varies with the views of the latest monographer. Nevertheless, taking only the older and generally accepted families and analyzing habits, we find the situation to be as follows:

Of 33 families of Hymenoptera, but 2 are strictly plant-feeding; the Cynipidæ, or gall flies, are in the main injurious to plants, but some forms are parasitic; 9 families are strictly parasitic upon other insects; 15 are predatory upon other insects; 2, comprising the bees, have no other especial value in their relations with man than as pollenizers of plants, or producers of honey; 3, comprising the ants, are beneficial as scavengers, but injurious in their other relations. It must be remembered, however, that at least 27 of the 33 families are of the greatest value in the cross-fertilization of plants, in which work the insects of this order perhaps take the lead.

In the Coleoptera, or beetles, considering 82 families, the insects of 9 families on the whole are injurious, and of 23 families on the whole are beneficial as destroying injurious insects; 10 families are beneficial as scavengers, and 30 or more, mostly small groups of little importance, contain some scavengers and many neutral forms of practically no economic importance, although certain of them visit flowers; 2 families contain both injurious and beneficial forms, as well as many that are neutral.

In the Siphonaptera, or fleas, the species of the single family are parasitic upon warm blooded animals.

In the Diptera, or true flies, if we classify the families according to habits of the majority of the species in each, we get approximately injurious families, 10; predaceous families, 11; parasitic family, 1; scavengers, 19. In point of numbers, of individuals in this order, as well as in the Coleoptera, no doubt the injurious will exceed the predaceous; while in the Diptera the scavengers will probably equal all of the others put together.

In the Lepidoptera practically all of the 60 odd families are injurious through the damage done by their larvæ to vegetation, but here again it must be remembered—and the same comment holds for many of the Diptera which we have just considered—that the adult insects are among the most active and frequent visitors of flowers and have a great and beneficial effect on cross fertilization.

In the Trichoptera the insects of the single family feed upon aquatic plants and have no economic value except as furnishing food for food fishes.

The insects of the single family in the order Mecoptera are indifferent in their economic relations, though probably slightly beneficial.

In the Neuroptera all of the 7 families are beneficial through their predaceous habits, with the exception of the Sialidæ, which, since their larvæ are aquatic, may be termed indifferent or neutral, though it has both a beneficial and an injurious relation to food fishes.

In the Homoptera we have 9 families, all of which are injurious except that here and there a species has had a commercial value, like the lac and dye insects.

In the Heteroptera there are 11 families which are strictly plant feeders; 8 are strictly predaceous; 3 are both injurious and predaceous; while the economic value of 13 is more or less doubtful. Most of these last are aquatic and have some value as fish food.

The insects of the single family of the order Physaptera are injurious.

In the Orthoptera we have one family of strictly predaceous habits; one which has a mixed food and is partly injurious and partly beneficial as its species become scavengers; the habits of 1 family are unknown; while in the 4 remaining families the species are all injurious as destroyers of vegetation.

The insects of the single family of the order Euplexoptera are probably beneficial as predatory forms and scavengers.

The single family of the order Mallophaga is injurious, containing parasites of birds and mammals.

In the Corrodentia the habits of the insects of the single family are on the whole of little economic importance, though the species are to be classified in the main as scavengers.

In the Isoptera the forms belonging to the 2 families are injurious.

In the order Plecoptera the species of the single family are practically neutral in their economic relations, although they possess some value as fish food.

All of the insects of the single family of the order Odonata may be called beneficial; the adults are predaceous upon other insects and are thus strictly beneficial, but the larvæ may in a sense be termed injurious, since they are aquatic and prey upon other aquatic insects which themselves may be food for fishes.

The insects of the single family of the order Ephemerida are of little economic value, except that they are important fish food.

Lastly, the insects of 8 of the families of Thysanura are beneficial as scavengers and soil makers, while some of the species of 1 family are somewhat harmful from the damage which they do in households.

Tabulating the facts thus gained, we have the following:

Injurious as feeding upon cultivated and useful plants, the insects of 112 families.

Injurious as parasitic upon warm-blooded animals, the insects of 1 family.

Beneficial as preying upon other insects, the insects of 79 families.

Beneficial as scavengers, the insects of 32 families.

Beneficial as pollenizers only, the insects of 2 families.

Beneficial as forming food for food fishes, the insects of 3 families.

Of undetermined economic importance, the insects of 49 families.

Families containing both injurious and beneficial forms, 22.

The totals are:

Beneficial, the insects of 113 families.

Injurious, the insects of 116 families.

Both or undetermined, the insects of 71 families.

CONCLUSION.

And now the question is: Are we any nearer the answer of the query in the title of this paper than we were at the start? We have, perhaps, gained by this summary a clearer idea of the economic importance of the class Insecta, and possibly it may appear by this contrasting method that the benefits derived from insects entirely offset their injuries; but we cannot, in our present stage of enlightenment (and I say it with all reverence), complacently and piously adopt, with the good old rector of Barham, the view that insects, with all the lower animals, were created for man's benefit, God permitting occasional injuries, to use Kirby's words, "not merely with punitive views, but also to show us what mighty effects he can produce by instruments so insignificant, thus calling on us to glorify his power, wisdom, and goodness."

Contrast with this view the view of Prof. Bailey, in one of his charming essays in the volume entitled "The Survival of the Unlike:" "We are now prepared to admit that this whole question of enemy and friend is relative, and does not depend upon right and wrong, but simply upon our own relationships to the given animals and plants. An insect which eats our potatoes is an enemy, because we want the potatoes too; the insect has as much right to the potatoes as we have. He is pressed by the common necessity of maintaining himself, and there is every evidence that the potato was made as much for the insect as for the human kind. Dame Nature is quite as much interested in the insect as in man. 'What a pretty bug!' she exclaims; 'send him over to Smith's potato patch.' But a bug which eats this insect is beneficial; that is, he is beneficial to man, not to the insect. Thus everything in nature is a benefit to something and an injury to something; and every time that conditions of life are modified the relationships readjust themselves."

In these words Bailey, with his accustomed felicity, has expressed the situation admirably. Man is but one of the forms of life struggling for existence, at continual warfare with surrounding forms; but by virtue of his surpassing intelligence—itself as gradually evolved as have been the physical characteristics of any given species—he has overrun the earth, has accommodated himself to the most unnatural environments; he has dominated all other species in nature; he has turned to his own uses and encouraged or hastened the evolution of species useful to him or of useful qualities in such species; he has wiped out of existence certain inimical forms, and is gaining the control of others. He is the dominant type, and types whose existence and methods of life are opposed to his interests are being pushed to the wall. It is the culmination of a history which has many times repeated itself in past ages. The struggle of other forms of life to accommodate themselves to the conditions brought about by the rapid development of this dominant type is one of the most interesting fields of study open to the biologist to-day. It would seem as if, in man's efforts to make the face of the earth his own, all the complicated elements of life were arrayed against him, and the great and ultimate result of the labor of the biologist in his study of the relations of the different forms of life and the laws which govern their development will be to bring about the absolute control of all other life by man. Thus it is not only the economic worker who looks for immediate results of a practical kind from his labor—the scientific agriculturist, the horticulturist, the economic zoologist, the medical bacteriologist—who should command the respect of even the practical-minded man, but the biologist in whatever field, however restricted it may be, whether he is working toward the understanding of broad principles and general laws, or whether, in some narrow corner of research, he is accumulating material which will help ultimately to lead to wider understandings—all are working helpfully and practically toward the perfect well-being of the human race.

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**The thirty** forest reservations of the United States embrace an area of 40,000,000 acres in thirteen States and Territories. Seven are in the State of California, the largest of which, the Sierra Forest Reserve, includes 4,000,000 acres. Within the past thirty-five years it is estimated that 11,000,000,000 feet B. M. of timber on public land have been destroyed by forest fires.

## THE NEW BONN BRIDGE OVER THE RHINE.

LIKE a rainbow, the great arch of the new Bonn bridge boldly spans the Rhine in the sight of Alma mater Bonnensis. With a clear distance between the two main piers of 187·92 meters (616·38 feet) and a height of 45·50 meters (149·24 feet) above low watermark, the arch is, without doubt, the largest ever built in an iron bridge. The upper chord lies entirely above the bridge; while the lower chord at each end intersects the roadway at a distance of 16 meters (52·48 feet) from the piers, and is anchored below the roadway. The supporting rods at both sides of the arch have a horizontal distance at the center of 9 meters (29·52 feet) between perpendiculars, thus producing a roadway 7 meters (22·96 feet) wide and two footpaths each 3·5 meters (11·48 feet) wide. The footpaths on each side are bracketed out 2·5 meters (8·2 feet). The upper edge of the roadway is 22 meters (72·16 feet) above low tide, leaving, for a length of 164 meters (537·92 feet), a clear space of 7·5 meters (24·6 feet) between the bridge-roadway and the masts or stack of a vessel at high water. The caissons for the central piers were sunk only 5 meters (16·40 feet), as the bed of the stream, for a depth of 15 meters (49·20 feet), consists of coarse and fine gravel resting on sandy, white, lignitiferous clay.

The central piers were begun in April, 1896, and brought up to the height of the bridge roadway about the end of March, 1897. By the first of September, the superstructure was completed; the false work by which it was supported was partially removed; and the bridge allowed to find its bearings on the piers. No shore structures had as yet been built, for which reason the central piers alone sustained the entire thrust. In spite of this enormous thrust, the piers yielded only 17 millimeters (10·663 inches). By Christmas, 1897, the entire false work had been removed; and the huge arch sustained only by the piers extended freely across the river.

The building of the two land-arches, each having a span of 34·45 meters (112·996 feet), the bridging of the street extending along the river-front, with its breadth of 32·95 meters (108·076 feet), and the general completion of the bridge approaches, required an entire year.

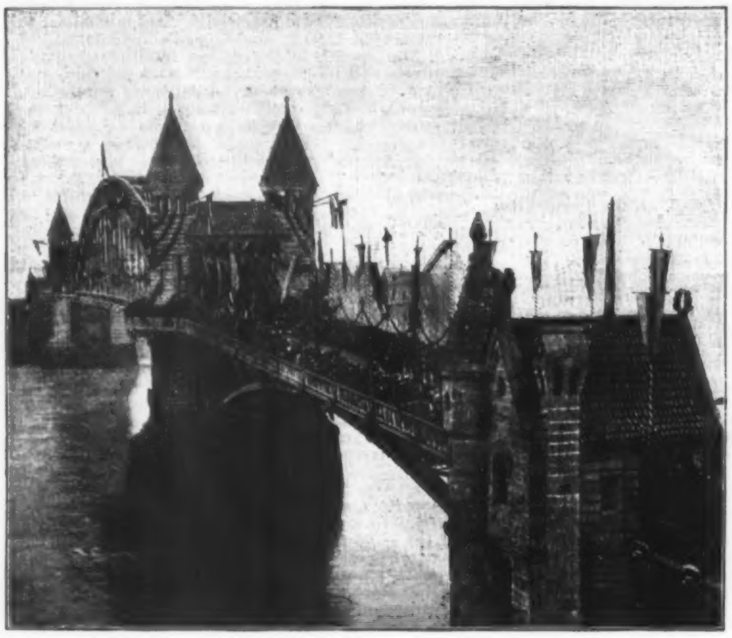
In constructing the bridge, there were required 3,218 tons of basic steel, 22,000 cubic meters (28,600 cubic yards) of masonry, and 7,000 cubic meters (9,100 cubic yards) of concrete, including 3,270 tons of cement.

A bridge is essentially a utilitarian structure designed to meet the requirements of commercial life. Up to a few years ago engineers concerned themselves chiefly with the building of bridges with as little money as possible, and with the primary object in view of providing accommodation for the largest possible amount of traffic. All other considerations were subordinated to these. Artistic forms were used only to a limited extent and only in so far as they were cheap and directly applicable to the structure in hand. But at the building of the Mainz and Düsseldorf bridges the utilitarian spirit was not allowed entirely to triumph. The city of Bonn very reasonably laid great stress upon the erection of a bridge which would constitute a gateway worthy of the incomparable highway of the Rhine. With this object in view, the two main piers have been built in the form of tower-flanked castle-gates, each with a broad central passageway and two side roads. On the two shore-piers, turreted toll-gates have been erected. The architecture of these structures strikingly resembles that of the medieval castles on the Rhine.

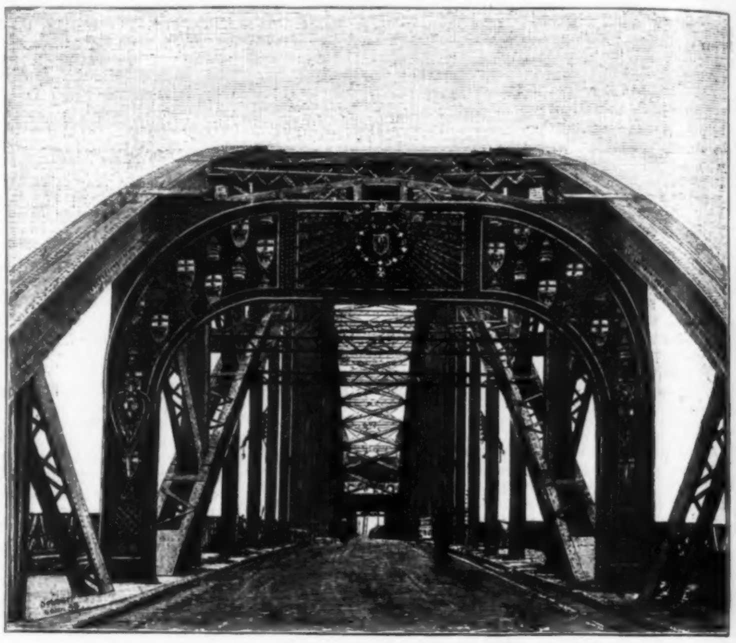
The entire bridge has cost in round numbers 4,000,000 marks ($1,000,000), and has supplanted the old ferry, the franchise of which was granted as early as July 31, 1325, by Heinrich von Virneburg, Archbishop of Cologne, and was bought up by the city for 200,000 marks ($50,000). At no distant day an electric railway will run from the city-station, over the bridge, and up the right bank of the river to Ehrenbreitstein.

That the 70,000 people living in the vicinity of the bridge appreciate full well the advantages and beauty of the structure is proved by the extraordinary number of visitors to the bridge on the Sunday following the formal opening. On this day the bridge tolls amounted to 2,435 marks ($609). The patriotic citizens of Bonn will have to put their hands deep into their pockets before they have fully relieved themselves of the debt incurred by the building of the bridge. But, by the pledges which they have given, they have made possible a work which now constitutes one of the sights of Bonn. Moreover, Rhine tourists will now be attracted in larger numbers to the city, especially since the Siebengebirge can be so readily reached by the electric road.

The Siebengebirge, it should be mentioned, have at last been saved from the hungry quarrymen, who were



THE OPENING CEREMONIES AT THE WEST GATE ON DECEMBER 17, 1898.



WIND-BRACE AT THE WESTERN END OF THE CENTRAL ARCH.

THE NEW BRIDGE OVER THE RHINE AT BONN, BUILT BY PROF. REINHOLD KROHN.

gnawing away the hills from all sides. In order to preserve this paradise of the Rhine, the Provinziallandtag granted the quarry owners 200,000 marks, the city of Cologne 100,000 marks, the city of Bonn 50,000 marks, and the Prussian ministry gave them the right to start a lottery. It is, therefore, to be hoped that the hundred thousand tourists who annually visit the region will no longer hear the blasting of rock and the pounding of hammer against stone; that the deserted, ruined slopes will again be clad in green; and that the broad forests will once more offer to many the rest and refreshment which they seek.

Our illustrations have been taken from the Illustrirte Zeitung and Ueber Land und Meer.

## THE AUTO-LUX.

### APPARATUS FOR LIGHTING AND EXTINGUISHING GAS AT A DISTANCE.

ONE of the advantages of the electric lamp is that it may be lighted and extinguished at a distance. In ordinary life, this is a great convenience, since a person is often obliged to feel his way in the dark in order to light the gas or a candle. But, since, for a host of different reasons, every one cannot have electric light, many inventors have endeavored to devise an apparatus that shall give the same lighting and extinguishing facilities for gas. We have already given a description of several arrangements devised for this purpose, but, in all of these, recourse was had to quite a complicated mechanism that acted upon a cock of which the operation was not sure, owing to the fact that an electro-magnet was generally used and the force at one's disposal was quite feeble. It follows that, in such a case, if the cock is somewhat tight, it will not turn, and, if it is too loose, the gas will leak. It is probably for these reasons that the systems hitherto brought out have not been very successful. But the idea has not, on that account, been abandoned, and the fierce contest waging between gas and electricity explains the new tentatives making in this direction. The "Auto-Lux," illustrated herewith from La Nature, appears to be the simplest apparatus of all those that have been constructed up to the present, since in reality it includes no mechanism. The cock is replaced by a steel ball, *B* (Fig. 1), which rests upon a seat situated at the extremity of the conduit that leads the gas, and which it thus closes hermetically. The precision with which balls are now made for bicycle bearings permits of relying upon a perfect closing of this kind. The weight of the ball, moreover, is such that the pressure of the gas can in no case displace it. The ball is inclosed in a chamber, *H*, closed by a cover, *C*, upon which is screwed the burner. In this chamber there is a permanent magnet, *A*, between the poles of which debouches the extremity, *E*, of an electro-magnet, *F*. By means of these elements, it is possible, at will, to move the ball to the left or the right, that is to say, to move it from its seat or replace it thereon. To this effect, it suffices to send into the electro-magnet a current that shall determine at will a north or a south pole in the extremity of the core, *E*.

For this purpose there are special buttons (Fig. 2) terminating in a head, *M*, that may be turned to the right or left. The negative of the battery communicates with a block, *Z*, which, in a state of rest, is touched by two flat springs, *L* and *T*. The positive is connected with two blocks situated on each side of these springs, which, in a state of rest, do not touch them. These are connected with the extremities of the wire of the electro. If we turn the head, *M*, to the right or left, we shall cause one of the springs to touch one of the positive blocks, while the other remains upon the negative, and the current will circulate in one direction or the other, according to the spring set in motion. In this way, the pole that we have chosen will be determined at the extremity of the core of the electro. As soon as the current passes into the electro, the ball will be attracted and remain in contact therewith. As the seat upon which it rested will be uncovered, the gas will flow into the chamber, *H*, and thence to the burner. At the same time, it will flow through an aperture in the chamber communicating with a small tube, *P*, above which there is a platinum wire raised to incandescence by the passage of the current.

It is here that it ignites and lights the principal burner. The head of the button being no longer maneuvered, the springs resume their first position. But things are so arranged that the pole of the permanent magnet that has a polarity contrary to that assumed by the ball attracts the latter through its contact with the electro and causes it to fall upon a seat terminating the aperture of the tube, *P*, designed for lighting the gas. For extinguishing the gas, the same button is used, the head being turned in the contrary direction. The ball is again attracted; but, as soon as the current is no longer passing (the ball having taken on a polarity reverse to that of the preceding), it is the other pole of the permanent magnet that attracts, and the ball falls upon the seat of the principal gas conduit.

The current necessary for the proper operation of the apparatus is one of 5 amperes. The batteries employed are Leclanché ones of wide surface, which easily give such intensity; and, as each emission is of very short duration, they may be used for a long time.

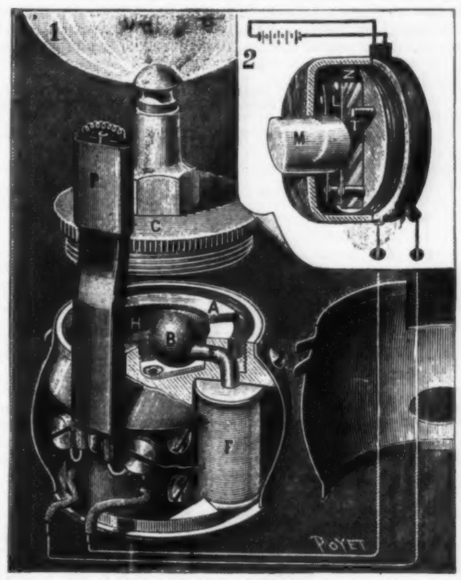
## HISTORY, DEVELOPMENT AND VARIETIES OF THE PIN AND NEEDLE.*

THERE is no record of the period when pins and needles were first employed in their primitive forms. The earliest needles were not pierced at the end opposite the point; but the prehistoric needle was rather an awl, which served to make holes in furs or skins that were worn ages before textile fabrics were invented. The long underground roots of plants or bindweed, and leathern thongs, were passed by hand through the holes thus made; and it was only in more recent times that the idea was conceived of attaching the thong to the primitive needle, for forcing it to follow the path thus made, whence arose the first idea of the needle proper. In remains of the stone age splinters of stone, pierced with a hole at the end opposite the point, are met with; and it is evident that these tools, sometimes a little curved, served as needles in those remote periods.

Flat needles, with a split in the end opposite the point, are found among the remains of the bronze age, the two branches being slightly separated, then brought together again and crossed at their ends, whereby a kind of eye was formed, while the two parts were sometimes united by a rivet. It is not known when the eye was first formed by piercing the end, which must have been a difficult operation on a cylindrical rod of iron or steel, so that, subsequently, the place was flattened where the eye occurs; but no correct idea can be formed as to the shape of these needles, because they could not withstand atmospheric influences, while, on the contrary, specimens of the early pin, for which bronze or the precious metals were often employed, have been very well preserved. The true type of a sewing needle was, so early as the Greek and Roman times, pointed at one end and pierced at the other; and it was only when the sewing machine was invented that needles were made with the eye near the point.

Even if the period when the first true needle made its appearance be unknown, as also its exact form, there can be no doubt that this essentially domestic implement had attained a very high degree of perfection in ancient times. So ancient a poem as Homer's "Odyssey" gives a detailed account of the mantle woven and embroidered by Penelope for Ulysses, on his departure for the Trojan expedition. It was not, however, women only who used the needle, because needlework ranked among the fine arts, and it is probable that the embroiderers of the period made their own needles, just as, so late as a century or two ago, painters made their brushes and prepared their own colors.

It was only about 1785 that the first mechanical process producing the double steel rod, for making two needles joined together, was introduced. At first needles, before they were completely finished, underwent a great many manual and mechanical operations, passing several times between the factory and the workman's dwelling; and it was only about 1870 that the needle was made for the most part by mechanical methods, while during the last fifteen years only has it been entirely finished in this manner.



THE AUTO-LUX.

1. Details of the apparatus. 2. Maneuvering button.

After Sheffield, Aachen, or Aix-la-Chapelle, has been celebrated for the needle industry during the last two centuries; and it is in that city that were established the first mechanical appliances connected with it. Before the invention and perfection of the pointing machine, a skillful workman could point 25,000 needles in a day of ten hours; but a machine now performs this operation with greater precision on 300,000 needles in the same time and with one workman.

The needle manufacture is now concentrated in England, the United Sates of America, and Germany, viz., at Aix-la-Chapelle, which is by far the most important seat, and also at Iserlohn, Altona, Schwabach, Chemnitz, and Ichterhausen. While no needles are made in France, that country produces a large quantity of pins—it is stated ten thousand millions—while consuming more than ten millions daily, so that French imports of this domestic article are considerable.

There are at least 250 varieties of the needle for sewing alone, to say nothing of those for embroidery, packing, cartridge-making, book-binding, sail-making, knitting, larding (in cookery), and many other purposes more or less connected with the original object.

The pin called Steck-Nadel in German has even more varieties than the needle, while being still more largely and generally used. The pin must also have been employed before the needle, for connecting the skins which served as garments before the idea of sewing them together was conceived. Examples of artistically wrought pins are found among Egyptian as well as Greek remains; but it was especially the Romans who made very elaborate fibulæ, which have developed into the modern brooch. Simple pins with mere head, shank, and point were, however, largely used in antiquity; and the estimation in which they were held is proved by many proverbs and popular sayings connected with the pin in various languages.

Different kinds of wire are required for making the pin and the needle; for while that of the latter must be stiff and yet yielding, to a certain extent, as well as polished to the highest degree, that of the pin must also possess a certain amount of stiffness, while it must also permit of bending without being broken, though a too highly polished pin becomes easily detached. Scarcely a hundred years ago the steel pin was rarely used; but this variety has now been so much improved that the steel pin may be said to have now come into general use.

The lengths of steel wire are prepared in the same manner as those for the needle, so as to constitute two pins, separated into equal parts before the operation of heading; and one end must be softened before receiving the head. For this delicate operation alone an automatic machine has been devised, that brings each head in turn within the influence of small gas flames, and which can soften 150,000 shanks in a day, five or six machines being tended by one person. Very small brass or iron pins are headed by simply "upsetting" or crushing down the end, as in riveting; but for those of larger size, the heads must be prepared previously, in a particular and very ingenious manner, from a piece of wire twisted spirally, two and a half turns being required to make the head, of which 500,000 may be produced daily by one worker. Whereas before 1835 each pin was headed separately by hand, between five and six thousand pins may be now headed mechanically in ten hours.

Enamel-headed pins constitute a branch of industry special to Aix-la-Chapelle, where was first conceived the idea of adapting the "enamel" or glass head to the steel shank. A manufacturer of that city, seeking means for utilizing the needles spoilt in manufacture, conceived the idea, after visiting some Venice glass bead factories, of fixing the bead on the end of one of the "waster" needles, so as to form a pin; but it was only after long and tedious trials that he succeeded in attaching the enamel strongly enough to the shank, and also in finding a composition of glass sufficiently tough to stand the usage to which a pin may be subjected.

The general introduction of the steel pin was not easy, because it was found that the early examples readily became detached, owing to their high polish, while they often broke through want of sufficient pliability. During the last thirty years, however, the consumption of steel pins has greatly increased; and at a single Aix-la-Chapelle factory it has been found necessary to put up separate works to make the glass for heading pins, that now turn out half a ton of "enamel" daily for this purpose, while the same establishment consumes two-thirds of it. The consideration that only 0·2 gramme (3 grains) of this glass is, on an average, required for heading a pin, will afford some idea of the enormous quantity of pins that can be headed with half a ton.

Owing to the greatly increased consumption of steel pins, the "waster" needles now form only a very slight proportion of the shanks required. For preparing the latter, pointed lengths of iron wire are introduced, a million together, into a cast iron drum containing a special carbon dust for cementing them—i. e., turning them into steel, by subjecting them to the necessary heat during a certain length of time. This process imparts the necessary degree of hardness; and the almost imperceptible flange formed in cutting the wire to length is favorable to the holding fast of the head, while it is seldom that an enamel-headed pin loses its head.

The enamel, or glass, has to be made specially for the purpose, because it must be easily fusible, and must also remain viscous sufficiently long for the forming of the head, while it must also be bright without the necessity for polishing, and yet not brittle. Two workmen with iron rods, like that of the glassblower, except that they are not hollow, take up on the end of them sufficient glass, which is rounded by turning so as to assume the form of a pear. With their rods they proceed quickly to a drawing-out walk, like a ropewalk, straight, horizontal, and about 50 meters (56 yards) long. Standing in the middle, the men unite the balls of viscous glass, and then proceed in opposite directions to the ends of the walk, thus drawing out the glass to the whole length, its thickness varying with the rapidity of the movement between three and seven millimeters (mean 3-16 inch), after which the glass rod is cut into lengths and made into bundles.

The head is formed and fixed at the same operation with great skill by a workwoman seated before a table, on which are mounted a frame, about 15 cm. (6 inches) high, carrying the glass rod placed horizontally (its end being brought to a convenient distance), a gas-burner at about the height of the rod and an air jet for giving a blowpipe flame, all adjustable. The workwoman, who has before her a quantity of steel shanks, takes several in each hand and passes each one in succession, alternately with the right and left, into the heated and viscous portion of the glass rod, withdrawing the shank by a special turning movement so as to take up a little of the glass; and a turn of the thumb and first finger gives the shank a rotary movement, so that the glass taken up becomes formed into a head which remains attached to the end of the shank, the head cooling while the complete pin falls into a channel. This somewhat complex operation is executed with remarkable address and rapidity; and a skillful worker can head from 25,000 to 30,000 pins daily. There are fifteen sizes of these pins, the heads of which vary in diameter from 1·5 to 3·5 millimeters—say from 1-16 to 1-8 of an inch—while the length of the shank varies from 1·5 to 5 centimeters (19-32 inch to 2 inches).

According to the report of the Aix-la-Chapelle Chamber of Commerce, there are now in that city forty pin and needle factories, employing more than 4,000 workpeople, or two-thirds of the total number engaged in that industry in Germany. For making needles alone from 800 to 900 tons of steel wire are worked up yearly; and the following are the numbers of the principal finished products that are turned out per annum:

Hand-sewing needles, 3,100,000,000; sewing machine needles, 65,000,000; various other needles, 35,000,000; and pins 1,300,000,000; making a total of 4,500,000,000, representing a value of 6,000,000 marks (£300,000), and giving a mean price of 1s. 4d. per thousand, although the prices actually vary from 7½d. to 8s. per thousand.

Of the lightest needles there are forty in a gramme, and, therefore, 1,200 in an ounce, while no less than 7,000 of the lightest enamel-headed steel pins go to a pound avoirdupois.

Manufacturers who produce none but needles of the highest quality complain bitterly that much harm is done to the Aix-la-Chapelle market by inferior products, which can scarcely be distinguished by their appearance from those of good quality. While a good

* "Die Nadel und ihre [illegible]ung, eine technologische Skizze," von Franz Büngerbach, Aachen, [illegible]z Schweitzer, 1898.—Journal of the Society of Arts.

needle may be bought at the rate of ten a penny, those of inferior quality are sold thirty for a penny; but the difference in price is far more than set off by frequent breakage, bad work, difficulty of threading, wearing of thread, and loss of time, to say nothing of temper. It is only the middle-man who gains by the bad needle, the producer and consumer both suffering.

## NUTRITION INVESTIGATIONS AT THE UNIVERSITY OF TENNESSEE.

By CHARLES E. WAIT.

THE investigations described herewith form a part of the inquiries made during the last three or four years, under the direction of the United States Department of Agriculture, with the funds appropriated by Congress "to investigate and report upon the nutritive value of the various articles and commodities used for human food."

The investigations previously made in the United States had been mostly confined to the New England and other Northern States, and in order that definite information regarding the food supply and consumption of people living under different conditions might be obtained, the University of Tennessee, at Knoxville, was selected as a representative place at which to make these studies under more particularly Southern conditions.

Says the director of the Office of Experiment Stations with reference to this work: "The University of Tennessee offered special opportunities for the successful prosecution of nutrition inquiries. The university has thoroughly equipped chemical laboratories, . . . and co-operated with the Department of Agriculture in the most generous manner, freely giving all the facilities of its laboratories and much of the time of its professor of chemistry and his assistants. When it became known in the city of Knoxville and vicinity that such investigations were in progress at the university, the people manifested great interest in them, and the press eagerly sought and widely diffused such general accounts of the nature and purpose of nutrition investigations as were furnished them from time to time."

Up to the present time the Department of Agriculture has published two bulletins descriptive of this work, viz.: Bulletin No. 29, "Dietary Studies at the University of Tennessee in 1895," and Bulletin No. 53, "Nutrition Investigations at the University of Tennessee in 1896-1897."

It is very gratifying to note that the promising results obtained from the investigations already published have led to their continuance at the University of Tennessee by the department during 1897-1898. These results have been completed and will be published in a separate bulletin entitled "Digestion Experiments, with special reference to the Metabolism of Nitrogen, in 1898."

As an evidence of the appreciation of the results of these investigations, the author has been notified that the department desires his co-operation in the continuance of the work during 1898-1899.

The investigations described include: 1. Five dietary studies of students' clubs at the University of Tennessee. 2. Three dietary studies of typical mechanics' families in Tennessee. 3. A study of the composition of a side of Tennessee beef. 4. Composition of a side of Tennessee mutton. 5. Composition of the flesh of twenty Tennessee chickens. 6. Twenty-one digestion experiments with healthy men.

In the prosecution of the investigations the writer had the valuable assistance of Mr. H. M. Smith, of Middletown, Conn., for a brief time, and of Messrs. C. A. Mooers, J. A. McDonough, C. O. Hill, and J. O. LaBach, of the University of Tennessee.

### COMPOSITION OF FOOD MATERIALS AND EXCRETORY PRODUCTS.

In connection with the work a number of analyses were made of various Tennessee food materials as well as of many samples of food not produced in Tennessee and also of a number of excretory products. The heats of combustion were determined by the bomb calorimeter, by Prof. W. O. Atwater, Middletown, Conn.

Analyses of the following samples were made: 52 samples of beef, 6 of mutton, 6 of pork, 21 of chicken, 3 of butter, 1 of cheese, 14 of milk, 3 of buttermilk, 2 of veal, 3 of fish, 1 of soup stock, 2 of eggs, 1 of mincemeat, 10 of bread, 3 of flour, 1 of wheatlet, 1 of cowpeas, 2 of potato chips, 1 of canned peas, 1 of turnip salad, 2 of canned corn, 1 of bananas, 1 of rice, 1 of apricots, 1 of canned tomatoes, 21 of feces, 19 of urine.

### SCOPE AND PLAN OF THE INVESTIGATIONS.

The methods followed in the dietary studies were essentially the same as those explained in Methods and Results of Investigations on the Chemistry and Economy of Foods (Office of Experiment Stations, Bul. No. 21) and in the reports of the Connecticut Storrs Experiment Station for 1891, 1892, 1893, and 1894.

The general plan of the investigation included an account of all food materials of nutritive value in the house at the beginning, that purchased during, and that which remained at the end of the experiment. In addition to this, all the kitchen and table wastes of the food were collected, taken to the laboratory and there weighed and analyzed. The amount of different food materials on hand at the beginning and received during the experiment were added; from this sum the amounts remaining at the end were subtracted. This gave the amount of each material actually used. From the amounts thus obtained and the composition of each material as shown by analysis, the amounts of the nutritive ingredients were estimated. From this again were subtracted the amounts of nutrients in the waste, and thus the amounts of nutrients in the food actually eaten were learned.

An account was kept of all meals, from which was calculated the equivalent number of meals for one man.

### METHODS OF ANALYSIS.

The methods employed for the analyses of the specimens of food are the same as those used by Atwater and Woods.*

* These methods are described in detail in reports of the United States Fish Commission for 1880, 1883, and especially 1888; The American Chemical Journal, vol. ix., pp. 425 to 435; and the reports of the Storrs (Conn.) Experiment Station.

The methods used in the analyses of vegetable foods were practically those recommended by the Association of Official Agricultural Chemists.

### THE DIETARY STUDIES.

The plan of these studies includes the accurate determination of the amounts and kinds of different food materials purchased and consumed during a given period, usually from seven to thirty days, by a family or boarding club; the collection and analysis of the food wasted, and the record of the age, sex, and occupation of the different persons making up the family or club, and the number of meals taken by each. From the amounts of the different food materials consumed and the composition of each material, as determined by actual analysis, or as assumed from tables of average composition, the actual amounts of nutrients contained in the food were calculated. From these are deducted the amount of nutrients in the waste.

As a rule, a woman requires less food than a man, and the amount required by children is still less, varying with the age. It is customary to assign certain factors which shall represent the amount of nutrients required by children of different ages and by a woman as compared with an adult man. These factors, which are based in part upon experimental data and in part upon arbitrary assumption, are as follows:

Factors used in calculating meals consumed in dietary studies:

One meal of woman equivalent to 0·8 meal of man at moderate muscular labor.

One meal of boy 14 to 16 years of age, inclusive, equivalent to 0·8 meal of man.

One meal of girl 14 to 16 years of age, inclusive, equivalent to 0·7 meal of man.

One meal of child 10 to 13 years of age, inclusive, equivalent to 0·6 meal of man.

One meal of child 6 to 9 years of age, inclusive, equivalent to 0·5 meal of man.

One meal of child 2 to 5 years of age, inclusive, equivalent to 0·4 meal of man.

One meal of child under 2 years of age, equivalent to 0·3 meal of man.

By means of the preceding factors it is easy to calculate the number of meals of one man which would be equivalent to those actually eaten by the different persons. This value divided by three gives the equivalent number of days for one man. The total quantity of nutrients consumed divided by the equivalent number of days for one man gives the quantities "per man per day," the unit by which dietaries are ordinarily compared.

DIETARY NO. 39—THE COLLEGE CLUB.

(Duration of Study, Seven Days.)

The members and the number of meals taken was as follows: 41 men, 845 meals; 1 woman, 17 meals; 3 girls, 42 meals; equivalent to one man 301 days.

DIETARY NO. 40—THE COLLEGE CLUB.

(Duration of Study, Fourteen Days.)

The members and meals were as follows: 41 men, 1,747 meals; 1 woman, 34 meals; 3 girls, 88 meals; equivalent to 1 man 623 days.

DIETARY NO. 41—THE COLLEGE CLUB.

(Duration of Study, Seven Days.)

43 men, 918 meals; 2 women, 27 meals; 3 girls, 42 meals; equivalent to 1 man 329 days.

DIETARY NO. 42—A MECHANIC'S FAMILY.

(Duration of Study, Seven Days.)

4 men, 83 meals; 3 women, 50 meals; 1 child, 6 meals; equivalent to one man 46 days.

DIETARY NO. 181—A MECHANIC'S FAMILY.

(Duration of Study, Fourteen Days.)

1 man, 42 meals; 3 women, 73 meals; 2 boys, 29 meals; equivalent to 1 man 48 days.

DIETARY NO. 182—A MECHANIC'S FAMILY.

(Duration of Study, Fourteen Days.)

1 man, 116 meals; 1 woman, 82 meals; child, 1 meal; equivalent to 1 man 66 days.

DIETARY NO. 207—STUDENTS' CLUB.

(Duration of Study, Fourteen Days.)

90 men, 3,533 meals; 9 women, 276 meals; 1 child, 25 meals; equivalent to 1 man 1,278 days.

DIETARY NO. 208—STUDENTS' FARM CLUB.

(Duration of Study, Fourteen Days.)

13 men, 371 meals; 5 women, 90 meals; 1 child, 3 meals; equivalent to 1 man 155 days.

### DISCUSSION OF RESULTS.

Three of the studies here reported represent the food consumption of families of mechanics who were engaged in more or less active muscular work. It seems fair to assume that the work was moderately severe. Five are of clubs of college students; that is, of young men engaged in mental rather than muscular exercise. For purposes of comparison the results of the dietary studies of mechanics' families and college clubs in Tennessee and elsewhere are summarized in the accompanying tables. In the first table are shown the costs of the food and total amounts of protein and fuel value per man per day in the different dietaries. The proportion of the total cost, total protein, and total fuel values in the animal and in the vegetable food materials are also stated.

*TABLE showing costs, amounts of protein and fuel value of total food, and proportions in animal and vegetable foods, as purchased in the Tennessee, as compared with other dietaries*

[Amounts per man per day.]

| DIETARIES OF COLLEGE CLUBS. | Cost. | Protein. | Total Value | Proportion of Total Cost | | Proportion of Total Protein | | Proportion of Total Fuel Value | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | In Animal Food | In Vegetable Food | In Animal Food | In Vegetable Food | In Animal Food | In Vegetable Food |
| | Cts. | Grams | Calories | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. |
| In Tennessee (No. 39) | 18 | 109 | 3,870 | 54.2 | 45.8 | 50.7 | 49.3 | 40.1 | 59.9 |
| In Tennessee (No. 40) | 18 | 106 | 3,760 | 59.3 | 40.7 | 52.4 | 47.6 | 37.2 | 62.8 |
| In Tennessee (No. 41) | 19 | 98 | 3,880 | 57.1 | 42.9 | 48.5 | 51.5 | 36.2 | 63.8 |
| In Tennessee (No. 207) | 18 | 132 | 3,760 | 34.2 | 65.8 | 68.9 | 31.1 | 46.5 | 53.5 |
| In Tennessee (No. 208) | 15 | 72 | 3,820 | 39.8 | 60.2 | 33.4 | 66.6 | 42.0 | 58.0 |
| Average 5 Clubs in Tennessee | 18 | 103 | 3,820 | 48.9 | 51.1 | 50.8 | 49.2 | 40.4 | 59.6 |
| Average 5 Clubs in Connecticut* | | 127 | 3,880 | ...... | ...... | 67.7 | 32.3 | 53.2 | 46.8 |
| Average 5 Clubs in Maine† | 27 | 159 | 5,440 | 70.4 | 29.6 | 62.9 | 37.1 | 47.5 | 52.5 |
| Average 3 Clubs in Missouri‡ | | 107 | 3,920 | ...... | ...... | 58.9 | 41.1 | 49.2 | 50.8 |
| DIETARIES OF MECHANICS' FAMILIES. | | | | | | | | | |
| In Tennessee (No. 42) | 16 | 119 | 4,435 | 66.7 | 33.3 | 52.9 | 47.1 | 52.1 | 47.9 |
| In Tennessee (No. 181) | 12 | 106 | 4,400 | 63.0 | 37.0 | 35.9 | 64.1 | 45.6 | 54.4 |
| In Tennessee (No. 182) | 19 | 106 | 2,995 | 53.9 | 46.1 | 55.0 | 45.0 | 48.4 | 51.6 |
| Average 3 families in Tennessee | 16 | 110 | 3,945 | 61.2 | 38.8 | 47.9 | 52.1 | 48.7 | 51.3 |
| Average 9 families in Connecticut* | ...... | 113 | 3,605 | ...... | ...... | 61.1 | 38.9 | 47.9 | 52.1 |
| A family in New Jersey§ | 28 | 103 | 3,530 | 53.6 | 46.4 | 60.2 | 39.8 | 44.1 | 55.9 |
| A family in Indiana¶ | 26 | 106 | 3,840 | 50.0 | 50.0 | 58.5 | 41.5 | 42.7 | 57.3 |

*Connecticut Storrs Sta. Rpt. 1896, p. 152.
†U. S. Dept. Agr., Office of Experiment Stations Bul. 37.
‡U. S. Dept. Agr., Office of Experiment Stations Bul. 31.
§U. S. Dept. Agr., Office of Experiment Stations Bul. 35.
¶U. S. Dept. Agr., Office of Experiment Stations Bul. 32.

*TABLE showing Protein and fuel value, and estimated costs of the food actually eaten and of that wasted in the Tennessee, as compared with other dietaries.*

[Amounts per man per day.]

| DIETARIES OF COLLEGE CLUBS. | Waste. | | | Food Eaten. | | |
|---|---|---|---|---|---|---|
| | Estimated Cost | Protein | Fuel Value | Estimated Cost | Protein | Fuel Value |
| | Cents. | Grams. | Calories. | Cents. | Grams. | Calories. |
| In Tennessee (No. 39) | 3 | 16 | 390 | 15 | 93 | 3,480 |
| In Tennessee (No. 40) | 2 | 13 | 310 | 16 | 93 | 3,450 |
| In Tennessee (No. 41) | 2 | 10 | 245 | 17 | 88 | 3,635 |
| In Tennessee (No. 207) | 1 | 9 | 165 | 17 | 123 | 3,595 |
| In Tennessee (No. 208) | 1 | 6 | 300 | 14 | 66 | 3,560 |
| Average 5 clubs in Tennessee | 2 | 11 | 275 | 16 | 92 | 3,545 |
| Average 5 clubs in Connecticut | ...... | 21 | 575 | ...... | 106 | 3,290 |
| Average 5 clubs in Maine | 6 | 38 | 1,180 | 21 | 121 | 4,260 |
| Average 3 clubs in Missouri | ...... | 11 | 360 | ...... | 96 | 3,560 |
| DIETARIES OF MECHANICS' FAMILIES. | | | | | | |
| In Tennessee (No. 42) | 2 | 9 | 345 | 14 | 110 | 4,090 |
| In Tennessee (No. 181) | 1 | 9 | 340 | 11 | 97 | 4,060 |
| In Tennessee (No. 182) | 2 | 11 | 175 | 17 | 95 | 2,820 |
| Average 3 families in Tennessee | 2 | 10 | 285 | 14 | 101 | 3,660 |
| Average 9 families in Connecticut | ...... | 7 | 185 | ...... | 106 | 3,420 |
| A family in New Jersey | 1 | 3 | 95 | 27 | 100 | 3,435 |
| A family in Indiana | 4 | 16 | 555 | 22 | 90 | 3,285 |

In the second table comparisons are made between the proportions of food eaten and that thrown away in the different dietaries.

As the tables show, the amount of protein actually consumed per man per day by the college club at Knoxville was quite variable, ranging from 66 to 123 grammes, with an average of 92 grammes. The available energy or fuel value of the food actually consumed was much more uniform, the range being from 3,450 to 3,635 calories, and the average 3,545 calories per man per day. The daily waste of protein averaged 11 grammes,

or about 11 per cent. of the total amount purchased, while the waste of fuel ingredients averaged about 7 per cent. of the total amount in the food purchased.

The proportions of protein in the dietaries of the mechanics' families were a little larger than those of the students' club. The same was true of the fuel values. The proportions of waste were not far from the same as in the college clubs.

It will be seen that the averages of the protein and energy of the dietaries of the college clubs and families in Tennessee do not differ very greatly from the same factors in the dietaries of students' clubs and workingmen's families in similar circumstances studied elsewhere.

The commonly accepted dietary standard for a man at light work calls for 112 grammes of protein and a fuel value of 3,000 calories; that for a man at moderate muscular work for 125 grammes of protein and a fuel value of 3,500 calories. In general the results cited above show somewhat less protein and somewhat more energy than the standard. It is, however, known that within limits a deficiency of protein may be made good by an abundance of fat and carbohydrates, i. e., energy.

### COMPOSITION OF DIFFERENT KINDS OF MEAT.

#### Composition of a Side of Beef.

Between thirty and forty samples of native Tennessee beef were analyzed in connection with dietary studies previously reported. These showed a considerably smaller amount of fat than is contained in similar cuts of Western beef as sold there in the Eastern markets.* For this reason it seemed desirable to determine the percentage composition of a complete side of native Tennessee beef of medium size and fatness. A side of beef slaughtered for the Knoxville market was selected for this purpose and was cut up according to local usages.† It was divided into seventeen cuts, of which eight belonged to the fore quarter and nine to the hind quarter.

A representative portion of several pounds weight was selected from each cut. The edible material was separated from the refuse (bone, gristle, etc.) and each carefully weighed, after which the edible portion was passed through a meat cutter. Samples were prepared for analysis in the usual manner, and were analyzed by the ordinary methods.‡

The results of these analyses are given in tabulated form.§

The available fuel values‖ per pound are calculated by use of the commonly accepted factors proposed by Rubner, which assigns 18·6 calories for each hundredth of a pound of protein (and carbohydrates) and 42·2 calories for each hundredth of a pound of fat.

It will be seen from this table that the Texas range beef is the leanest, though differing but little from Tennessee beef in this respect. The Colorado range beef comes third, followed by that raised in New England. The beef from the grain-producing States, Illinois and the neighboring region, is by far the fattest, containing nearly two and one-half times the amount found in the Tennessee beef. It will also be noticed that in general the larger the amount of fat, the less the amounts of protein and water. The protein content of the side here analyzed is slightly larger than that of the other sides with which it is compared, with the exception of the Texas beef.

As far as protein is concerned, the sides of Tennessee beef, which were believed to be representative, seem to be superior to the average Western meat, but as regards the energy they fall considerably below the latter. The number of sides analyzed is, however, hardly sufficient for detailed and definite conclusions.

### COMPOSITION OF A SIDE OF MUTTON.

From the preceding data it appears that ordinary Western beef is fatter than that raised in Tennessee. For the purpose of learning whether this was true as regards other kinds of meat, a side of mutton (believed to be representative), which was raised in this State and slaughtered in Knoxville, was purchased and analyzed.¶ This side was divided into cuts according to the custom of the Knoxville market, which is the same as that of other markets.**

The above figures indicate that, as in the case of beef, this side of Tennessee mutton, which was believed to be representative, was leaner than the average Western mutton.

It will be seen that there is a considerable difference between the fat content of the fore quarter of the Tennessee and the Western mutton. The difference in the hind quarter is scarcely noticeable, so that, taking the side as a whole, there is much less variation than was found in the case of beef.

### [illegible] OF CHICKEN.

The low cost of raising chickens and the price at which they are sold in the Southern States, in addition to their nutritive value, make them an important article of food. Comparatively few analyses of Southern-grown chickens have been reported. Since chickens are such a common article of diet in large sections of the country, it was believed that a more extended study of their food value was desirable.

Twenty chickens of average size and fatness were purchased in the open market in Knoxville, at a cost of 2[illegible] cents each. They weighed, dressed, on an average 2·25 pounds, without the giblets—i. e., gizzard, heart, and liver. The chickens were prepared for analysis and samples taken as described.

In the following table the results of the average of 20 analyses are shown.

*TABLE showing composition of Tennessee chickens of medium fatness as found in the market.*

| | WEIGHTS. | | | PERCENTAGE COMPOSITION. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Edible Portion | Refuse, Skin, Bone, &c. | Refuse | Water | Protein | Fat | Ash | Fuel Value 1 Pound |
| | Lbs. | Lbs. | Lbs. | Per Ct. | Per Ct. | Per Ct. | Per Ct. | Per Ct. | Calories |
| Average, | 2.22 | 1.67 | .55 | 24.9 | 47.5 | 14.3 | 12.8 | .7 | 800. |

### DIGESTION EXPERIMENTS WITH MEN.

The value of food for nutriment depends not only upon the kinds and total amounts of nutrients it contains, but also upon the proportion of the nutrients which can be utilized in the body. In order that the food may be utilized it must be digested—that is, it must undergo chemical changes by which it is made capable of absorption. These changes take place with the aid of the various digestive secretions—i. e., the saliva, gastric juice, pancreatic juice, etc. Such portions of the food as resist the action of the digestive ferments and of the bacteria in the intestine are rejected in the feces.

It has been customary to treat the dry matter of the feces as a measure of the amounts of nutrients contained in the food eaten which have resisted the process of digestion. This involves an error, for the reason that the feces contain not only the undigested and incompletely digested residues of the food, but also a considerable amount of other materials commonly called metabolic products. These metabolic products consist chiefly of residues of the bile, mucus, and the gastric, pancreatic, and other digestive secretions, but they include other materials, such as epithelial debris from the intestinal walls.

To determine the exact quantities of nutrients digested it would be necessary to determine and make correction for the metabolic products, and numerous attempts have been made to elaborate methods for quantitative separation of the undigested food residues and the metabolic products of the intestinal secretions. While much valuable work has been done in this line, the methods are not yet as perfect as might be desired, and most investigators continue to follow the ordinary plan of taking the difference between the food and feces as the measure of the digestibility of the food.

While recent investigation indicates that the metabolic products make a much larger proportion of the intestinal secretion than has generally been assumed in the past, the error introduced by neglecting them in determining digestibility is not so great as might be supposed. The metabolic products represent material which, for the most part, has been used for the purposes of the digestion. In other words, they are not available to the body for the yielding of energy, nor can they be utilized for building tissue or protecting it from waste. They are, therefore, unable to perform the principal functions of food. In the sense that they are not available for either building or repair of body material or for the yielding of energy, it is not improper to class them with the undigested residue of the food. This is equivalent to saying that the difference between the feces and food may be taken as measuring the amount which is actually available to the body for the main purpose of nutrition. Viewing the subject in this light, and using the term digestibility in the sense of availability, the proportion of the food which is digested will be its total amount less the sum of the undigested residues and the metabolic products which are involved in the digestive process. This is practically equivalent to the current method and is the plan followed in the experiments here described.

To determine the digestibility of a given food material by the above method it must be either eaten alone or, with other material the digestibility of which, under the given conditions, is exactly known. Many experiments have been made with men and domestic animals to determine the digestibility of individual food materials when eaten alone. With domestic animals this may present no great difficulty. An ox, for example, will feed contentedly upon hay alone for an indefinite time; but with man the case is different, since any single food material soon becomes unpalatable, and in the attempt to live upon it alone the digestive processes may be disturbed. In experiments with mixed diet these processes are much more likely to be normal. The results of such experiments with mixed diet, together with those of experiments upon the digestibility of individual food materials, give data for the computing of the digestibility of different classes of food materials.* The experiments here described were made with mixed diet more or less varied.

### THE DETAILS OF THE EXPERIMENTS.

Twenty-one experiments were made in all. Of these thirteen were carried on during the winter of 1895–96 and eight the following season. There were two and sometimes three or four subjects, each receiving the same diet as regards kinds of food materials, but the quantities of each material were such as best suited the individual. One set of analyses thus sufficed for two or more experiments. The solid and liquid excreta were collected for the whole experiment and each sampled and analyzed according to the usual methods.

Each experiment began with breakfast and ended with supper the day following, making six meals, or two whole days. Perhaps this is too short a time to give the most accurate results, but in some cases it was as long as the subjects could comfortably continue the ration, and in one instance it was with difficulty that even six meals were taken.

The supper preceding each experiment consisted largely or wholly of bread and milk, with about half a gramme of charcoal. The charcoal colored the feces, and the bread and milk gave a distinctive consistency, so that in this way a very sharp separation could, as a rule, be made between the feces belonging to the experiment and those belonging to the food preceding. The separation at the close was made in a similar manner, the charcoal being taken for breakfast on the day following the completion of the experiment.†

### THE TABULAR RECORDS OF THE EXPERIMENTS.

Twenty-one tables give the data of the individual experiments.*

The total of each kind of nutrient in the food, less the corresponding undigested matter of the feces, gives the amount digested. The ratio of the amount digested to the total eaten is called the coefficient of digestibility and is usually expressed in percentages.

The total heat of combustion (potential energy) of the food eaten, less that of the feces, does not, however, give a true measure of the energy of the food that is available for use in the body. The reason for this is apparent when we take into account the potential energy of the organic matter eliminated in the urine. This organic matter consists chiefly of urea, but with a considerable amount of other compounds. In order then to obtain the actual amount of energy furnished by the food that is available for use in the body, allowance must be made not only for the fuel value of the solid but also of the liquid excreta.

Investigations made in connection with metabolism experiments show the average heat of combustion of one gramme of the dried and ash-free residue of urine was found to be 2·87 calories and the nitrogen content 0·34 of a gramme. This amount of nitrogen may be assumed to have resulted from the consumption of 2·13 grammes of protein (0·34 gramme nitrogen × 6·25 = 2·13 grammes protein). According to this assumption the unavailable energy from one gramme of digested protein would amount to 2·87 ÷ 2·13, or 1·35 calories.

### DISCUSSION OF THE RESULTS OF THE DIGESTION EXPERIMENTS.

If a person could subsist upon a single food material for any length of time, it would be a comparatively easy matter to obtain the coefficients of digestibility of different materials. There are, however, very few food materials with which this is practicable. Even if the diet is limited for a time to one particular kind of food, as milk, bread, or meat, there is no assurance that the proportions of the different nutrients digested will be the same as would be the case were the food combined with other materials in an ordinary mixed diet. As an example of the difference between the digestibility of a single food material and of the same material when used in a mixed diet may be cited experiments with bread and milk. The average of ten experiments with an exclusively milk diet (1) showed 92·1 per cent. of the protein and 96·3 per cent. of the carbohydrates to be digested. Five experiments made with an exclusively bread diet or with bread and sugar showed 82 per cent. of the protein and 99 per cent. of the carbohydrates to be digested. Five experiments with a diet of bread and milk† showed 97·1 per cent. of the protein and 98·7 per cent. of the carbohydrates to be digested. In other words, the protein in milk alone or in bread alone seems to be much less completely digested than when the two are eaten together. Whether the same would hold true of other food materials there is no certain means of knowing. But it would seem reasonable to suppose that more complete digestion would occur when the diet was nearly normal; that is, made up of a number of food materials.

These statements are, of course, to be interpreted in the light of what was said regarding metabolic products and the undigested residues of food in the intestinal excretion. That is to say, the percentages of nutrients which are taken as digested in these calculations represent the difference between the amounts in the food and the material excreted in the feces. It may be that part of the difference in the digestibility of the single food materials as compared with those of the mixed diet may be due to differences in the amounts of metabolic products excreted.

The results of the above experiments are summarized in the following table, which shows the coefficients of digestibility of the different nutrients as found in the experiments:

*TABLE with summary of the 21 digestion experiments here reported, showing coefficients of digestibility found.*

| KIND OF [illegible] | Total Organic Matter | Protein | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| Bread and Milk. Average of 4 Experiments, | 98.2 | [illegible] | 97.? | 98.6 | 78.7 |
| Bread and Beef. Average of 2 Experiments, | 95.6 | 94.0 | 94.3 | [illegible] | 75.5 |
| Bread, Milk and Eggs. Average of 2 Experiments, | 96.9 | 94.6 | 94.6 | 97.0 | 68.0 |
| Liberal Mixed Diet. Average of 11 Experiments, | 95.7 | 92.6 | 94.4 | 97.0 | 68.0 |

The Nitrogen Balance.—The nitrogen of the digested protein is sooner or later eliminated from the body in the urea and allied compounds of the urine. The amount of nitrogen in the urine is usually taken as a measure of the amount of protein actually consumed within the body. If the quantity of nitrogen in the digested protein is the same during a given period as that eliminated in the urine, the body is said to be in nitrogen equilibrium, i. e., it neither gains nor looses nitrogen. If there is a greater income of nitrogen in the digested food than outgo in the urine, the

* U S. Dept. Agr., Office of Experiment Stations, Bul. 28.

† U. S. Dept. Agr., Office of Expt. Stations, Bul. 53, p. 6.

‡ Connecticut Storrs Sta. Rpt. 1891, p. 47.

§ U. S. Dept. Agr., Office of Experiment Stations, Bul. 53, p. 7.

‖ Not all the energy contained in a food material is available for use in the body, because more or less escapes oxidation. Of the unoxidized or partially oxidized products the larger portion is excreted by the intestines. A smaller portion is excreted by the kidneys in the urea and allied organic substances. The unoxidized compounds of the urine come from material which has been digested. They consist mainly of residues of protein compounds, urea, creatinin, etc. Of the potential energy of the digested protein only about three-fourths becomes available in the body by cleavage and oxidation. The rest escapes in the nitrogenous compounds of the urine.

¶ U. S. Dept, Agr., Office of Experiment Stations, Bul. 53, p. 10.

** See U. S. Dept. Agr., Farmers' Bul. 34, and Yearbook, 1895, p. 572.

* See article on the Digestibility of Different Classes of Food Materials, by W. O. Atwater, in the Connecticut Storrs Sta. Rpt. 1896, pp. 186–189.

† For a further discussion of this subject see U. S. Dept. Agr., Office of Experiment Stations, Bul. 21, pp. 53–80.

* U. S. Dept. Agr., Office of Experiment Stations, Bul. 53, pp. 29–43.

† U. S. Dept. Agr., Office of Experiment Stations, Bul. 21, p. 61; Connecticut Storrs Sta. Rpt., 1890, p. 163.

body is storing nitrogen or protein, and vice versa, if the nitrogen of the urine is in excess of that of the digested food, the body is losing nitrogen or protein.

Under normal conditions the body remains in approximate nitrogen equilibrium. The fluctuations one way or the other will vary with the character and amount of the daily food and the muscular and other activity. In general the body will come into nitrogen equilibrium with any ordinary diet, provided the food is in sufficient quantity to furnish the necessary protein and energy. When the diet is changed so as to include a greater or a less quantity of nitrogen per day, the balance of income and outgo will be disturbed, and a certain time will be needed to establish the equilibrium with the new diet. The length of time will depend upon various conditions, including the kind and amount of food, and the habits and peculiarities of the subject.

Some time is required for the metabolized nitrogen to be conveyed to the kidneys and excreted in the urine. The interval during which the excretion of nitrogen lags behind the metabolism may be termed the "nitrogen lag." For certain experiments of fundamental importance in the study of the laws of nutrition it is essential to obtain more information than is now available regarding the length of this period of nitrogen lag and the conditions upon which it depends. Attention is being given to this in connection with experiments now being carried on. This subject has been discussed and some of the experiments made have been noted in a previous publication.*

The urine was collected during nineteen of the digestion experiments previously reported, and the nitrogen in it determined. With the aid of this additional data it was possible to determine the balance of nitrogen in the different experiments. This was done by subtracting (algebraically) the outgo in the urine and feces from the income in the food. From the gain and loss of nitrogen thus found, the gain or loss of protein was calculated. The results are given in tabulated form.†

The results of the investigations for 1898 are now in the hands of the Department of Agriculture and it is expected they will be published at an early day. These latter investigations consist of twenty-three digestion experiments with men, with mixed diet, including a special study of the metabolism of nitrogen in connection with experiments, at rest, and also during great muscular exercise, the amount of work done being measured in foot pounds.

There was also made a study of five composite food samples, and a series of experiments was undertaken with cotton seed meal with reference to its nutrient value, and its fitness as a food for man.



## MASSIVE LAVA FLOWS ON THE SIERRA NEVADA.

An account of "Some Lava Flows of the Western Slope of the Sierra Nevada, California," is given by Mr. F. Leslie Ransome, in Bulletin No. 89 of the United States Geological Survey, 1898. The area is described as having been worn down to a rough peneplain during the interval between the close of the Jura-trias and the beginning of the Miocene period. The rocks upon which this somewhat uneven peneplain has been carved are those of the so-called "Bedrock series" of the Gold Belt, and are of Jura-trias and earlier age. They consist on the lower slopes (or foothill region) of clay-slates, schists, limestones, quartzites and various igneous rocks; and on the higher slopes mainly of gneissic and granitic rocks.

Volcanic eruptions began during the Miocene period, and, accompanied by elevation and tilting of the peneplain, lasted to the end of the Pliocene. The first eruptions were rhyolitic, followed by the laying down of a great cloak of andesitic breccias and tuffs. The deposition of auriferous gravels both preceded and accompanied the piling up of volcanic materials. Thus the earlier accumulation of andesitic breccias and tuffs was interrupted by at least one period of considerable erosion during which a large stream, the predecessor of the present Stanislaus River, cut through the volcanic cover into the Bed-rock series along the greater part of its course. During subsequent eruptions massive flows of lava extended over limited areas, displacing the stream before mentioned, and following generally the course of the Stanislaus River, while andesitic breccias and tuffs were spread for hundreds of square miles over the western slope of the Sierra. Other more restricted flows of lava followed, and the volcanic period was brought to an end by fresh andesitic eruptions, as shown by breccias which rest on the massive flows of lava. To these lavas the author applies the name of Latite, derived from the Italian province of Latium, where there occur in abundance rocks closely related to those he describes. Mineralogically the Sierra Nevada latites are near and allied to ordinary andesites, but chemically they correspond between the andesites and trachytes ... rogger, and represent to the plutonic monzo ... the magma. The author would ... the effusive forms ... ite in a broad sense, and to include use the term ... as toscanite, vulsinite, and ciminite, such varie ... e been described by Washington in his studi ... which ... in the Italian volcanic regions.

A commission has investigated the cause of the recent landslip at Sasso Rosso, near Airlo, on the line of the St. Gothard Railway. If another landslide occurs, it is possible not only the whole village of Airlo will be overwhelmed, but one end of the great Gothard tunnel will also be entirly blockaded. A fort defends the entrance to the tunnel, and the engineers who occupy the fort have organized a series of watchmen who will watch the spot where the landslide is considered the most likely to occur. They will be on duty night and day, and at night the dangerous places will be illuminated by the rays of a search light. In case of danger, a cannon will be fired from the fort, which will warn the inhabitants of the dangerous zone to take refuge in the shaft of St. Gothard tunnel, which is not used since building operations in the tunnel were completed. Other points of safety have been indicated to them.

* U. S. Dept. Agr., Office of Experiment Stations, Bull. 44.

† U. S. Dept. Agr., Office of Experiment Stations, Bul. 53, p. 45.

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